Perth Long Term Ocean Outlet Monitoring Program (PLOOM)

2015–2016 Annual Report: Swanbourne

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Quality Assurance

BMT Oceanica Pty Ltd has prepared this report in accordance with our Health Safety Environment Quality Management System, certified to OHSAS 18001, AS/NZS 4801, ISO 14004 and ISO 9001: 2008.

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Contents

List of Figures

List of Tables

List of Appendices

Acronyms

ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
CFU	Colony-forming unit
CTWWC	Comprehensive treated wastewater characterisation
DIN	Dissolved inorganic nitrogen
DO	Dissolved oxygen
DoF	Western Australian Department of Fisheries
DoH	Western Australian Department of Health
EPA	Environmental Protection Authority
EQC	Environmental Quality Criteria
EQG	Environmental Quality Guideline
EQMF	Environmental Quality Management Framework
EQO	Environmental Quality Objective
EQS	Environmental Quality Standard
EV	Environmental Value
HEPA	High ecological protection area
LAC	Light attenuation coefficient
LEPA	Low ecological protection area
LOEC	Lowest observed effect concentration
MPN	Most probable number
NATA	National Association of Testing Authorities
NHMRC	National Health and Medical Research Council
NOEC	No observed effect concentration
OZI	Observed zone of influence
PLOOM	Perth Long Term Ocean Outlet Monitoring
TTC	Thermotolerant coliforms
TTM	Total toxicity of the mixture
TWW	Treated wastewater
WASQAP	Western Australian Shellfish Quality Assurance Program
WET	Whole of effluent toxicity
WWTP	Wastewater treatment plant

Executive Summary

This report documents the findings of the 2015–2016 Swanbourne ocean monitoring program. Results are reported in the context of the Environmental Quality Management Framework (EQMF) described in EPA (2015). The results are summarised in Report Card format (Table ES.1). The report cards contain colour-coded results, with the individual colours representing the extent to which the Environmental Quality Criteria (EQC) were met (Table ES.2–Table ES.4).

Table ES.1 Summary report card legend

Management response[1]	Colour
Monitor: EQG met (continue monitoring)	
Investigative: EQG not met (investigate against the EQS), EQS met (continue monitoring)	
Action: EQS not met (management response required)	

Note:
1. The required response following an exceedance of either the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS) is shown in parentheses.

Table ES.2 Summary report card for the Environmental Quality Objective 'Maintenance of Ecosystem Integrity'

Environmental quality indicator		EQC	Comments	Compliance[1]
Toxicants in treated wastewater (TWW)	Bioaccumulating toxicants	EQG	Cadmium and mercury in the undiluted TWW stream were measured at concentrations below the ANZECC/ARMCANZ (2000) values for 80% species protection	
	Non-bioaccumulating toxicants		The rate of initial dilution achieved on 16 February 2016 (1:129) was sufficient to reduce contaminant concentrations to values lower than the ANZECC/ARMCANZ (2000) triggers for 99% species protection	
	Total toxicity of the mixture (TTM)		The TTM for the additive effect of ammonia, copper and zinc after initial dilution (0.53) was lower than the ANZECC/ARMCANZ (2000) guideline value of 1.0	
	Whole of effluent toxicity testing		The lowest NOEC recorded during the reporting period was 100% TWW. No dilution of the TWW was required to achieve this NOEC	
Nutrient enrichment	Chlorophyll-a	EQG	The median chlorophyll-a concentration within the high ecological protection area (HEPA) was lower than the 80th percentile of historical reference site data	
	Light attenuation coefficient (LAC)		The median LAC within the HEPA was lower than the 80th percentile of historical reference site data	
Phytoplankton blooms	Phytoplankton biomass (measured as chlorophyll-a)	EQG	1. There were no instances where median chlorophyll-a levels in the HEPA exceeded 3-times the median of historical reference sites	

Environmental quality indicator		EQC	Comments	Compliance[1]
			2. No chlorophyll-a samples at any site (and any time) exceeded 3-times the median of historical reference sites	
Physical-chemistry	Organic enrichment	EQG	Dissolved oxygen saturation remained above 90% concentration over the monitoring period	
	Salinity	EQG	Within the HEPA, median salinity was within the 20th and 80th percentile of reference site data	

Notes:

1. Green (■) symbols indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS), respectively.
2. NOEC = no observed effect concentration; the highest concentration of TWW at which there is no statistically significant observed effect on gamete fertilisation.

Table ES.3 Summary report card for the Environmental Quality Objective 'Maintenance of Seafood for Human Consumption'

Environmental Quality Indicator		Comments	Compliance
Microbiological contaminants	Thermotolerant coliforms (TTC)	The median value for TTC concentrations derived from 120 samples collected over the 2013–2014, 2014–2015 and 2015–2016 sampling seasons (<10 CFU/100 mL) was less than the EPA trigger value of 14 CFU/100 mL	
		There were no TTC samples that exceeded 21 CFU/100 mL over the 3-season pooled dataset (n=120)	
Algal biotoxins	Potentially toxic phytoplankton species	There were no instances in the 2015–2016 monitoring period where toxic phytoplankton numbers were in excess of WASQAP guidelines (DoF 2007)	

Note:

1. Green (■) symbols indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS), respectively.
2. CFU = colony-forming unit, WASQAP = Western Australian Shellfish Quality Assurance Program.

Table ES.4 Summary report card for the Environmental Quality Objective 'Maintenance of Primary and Secondary Contact Recreation'

Environmental Quality Indicator		Comments	EQC	Compliance
Faecal streptococci	*Enterococci* spp.	The 95th percentile of *Enterococci* spp. concentration (10 MPN/100 mL) was less than the EPA trigger value of 200 MPN/100 mL	EQG (primary contact)	
			EQG (secondary contact)	
Algal biotoxins	Phytoplankton (cell concentration)	The median total phytoplankton cell concentration (24.4 cells/mL) was less than the EPA trigger value of 15 000 cells/mL	EQG	

Note:

1. Green (■) symbols indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS), respectively.

1. Introduction

1.1 Document purpose

This annual report documents the findings of the 2015–2016 ocean monitoring around the Swanbourne ocean outlet. Monitoring was completed according to Western Australia's Environmental Quality Management Framework (EQMF; EPA 2015).

1.2 Wastewater treatment plant infrastructure and discharge

The Subiaco wastewater treatment plant (WWTP) treats predominantly domestic wastewater from the central Perth area. The WWTP comprises ~95% domestic wastewater and less than 5% industrial wastewater. The Subiaco WWTP discharges ~56 ML/day of secondary treated wastewater (TWW) to the ocean through a sub-marine ocean outlet (~11 m depth) located offshore from Swanbourne Beach (Figure 1.1).

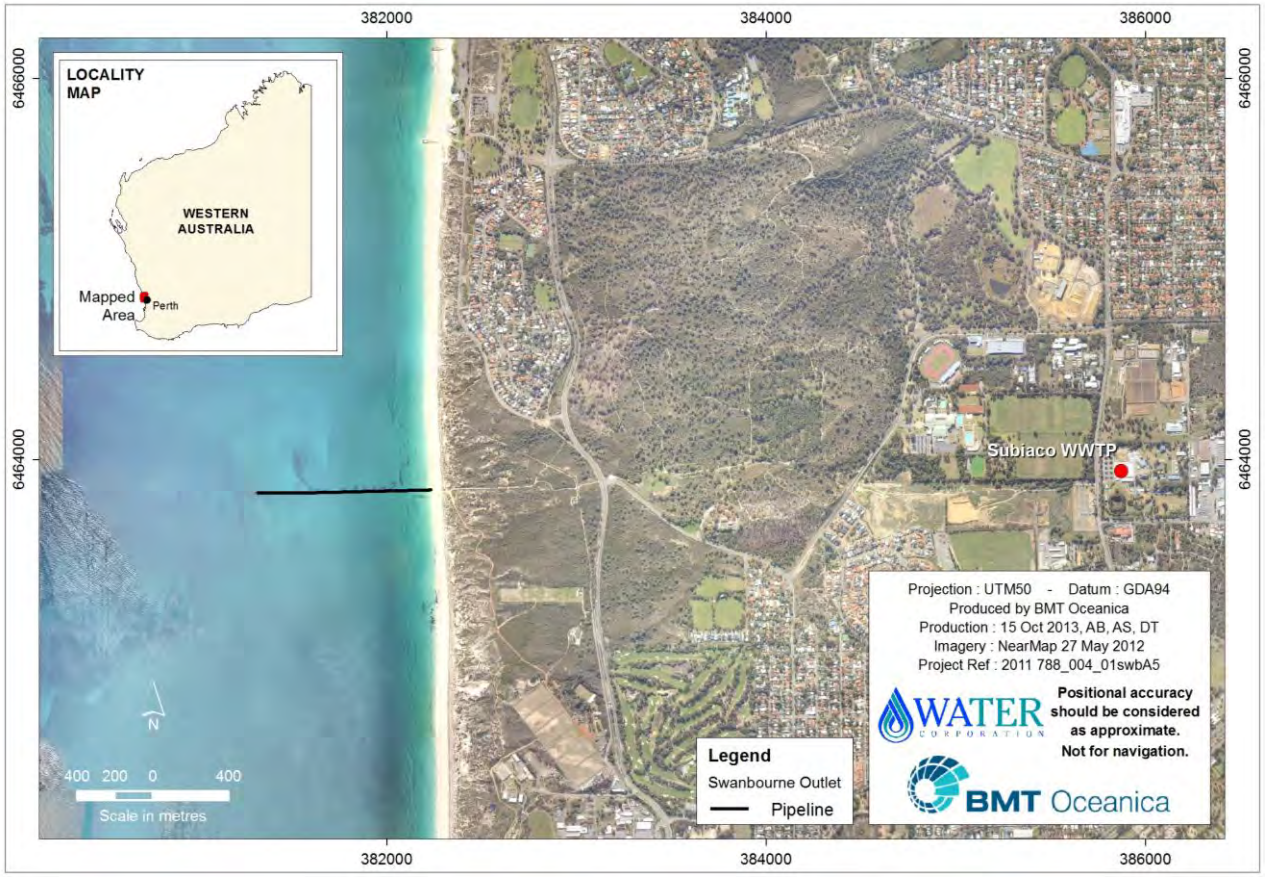


Figure 1.1 Location of the Subiaco wastewater treatment plant (WWTP) and Swanbourne ocean outlet

1.3 Potential stressors in treated wastewater

1.3.1 Toxicants

Metals and persistent organic compounds may be toxic to marine species or accumulate in biota at concentrations sufficient to pose a risk to humans when consumed. TWW is screened for bioaccumulating and non-bioaccumulating toxicants prior to discharge. To account for synergistic effects of multiple toxicants and toxicants without acceptable guidelines, the overall toxicity of the discharge is determined using whole of effluent toxicity (WET) testing (also known as direct toxicity assessment).

1.3.2 Physico-chemical stressors

TWW contains organic matter, decomposition of which by microorganisms uses oxygen. If more dissolved oxygen (DO) is consumed than is produced, DO levels decline. Measurements of DO saturation in receiving waters near the outfall, relative to measurements at reference sites, provides an indication of the risk posed by deoxygenation.

Reduced salinity near the outfall, resulting from freshwater in the TWW plume, may cause osmotic stress in marine biota. Similar to DO, measurements of salinity in receiving waters near the outfall are compared to the salinity at appropriate reference sites. The comparison allows evaluation of whether any reduction in salinity near the outfall is within the range of natural variability, as recorded at the reference sites.

1.3.3 Nutrients

TWW contains elevated concentrations of biologically available nutrients, including ammonia, nitrite, nitrate and orthophosphate. At times, the addition of nutrients may stimulate phytoplankton growth beyond natural levels, which under some circumstances may lead to shading of photosynthetic organisms such as seagrasses and/or macroalgae. The potential for shading is measured using in-water measures of chlorophyll-a (a measure of phytoplankton biomass) and light attenuation (a measure of water clarity).

Although most algal blooms are harmless, some contain species that produce toxins that may be harmful to swimmers (via ingestion or skin contact) or to seafood. For this reason, phytoplankton species composition and cell concentrations are monitored to ensure concentrations are within acceptable limits.

1.3.4 Microbial contaminants

Disease-causing organisms in the TWW pose a risk to humans if exposed during primary and/or secondary contact activities (i.e. swimming and boating). The same organisms if ingested by marine fauna may reduce their suitability for human consumption. To assess the risk, numbers of indicator organisms are routinely compared to the Environmental Protection Authority's (EPA's) criteria for primary and secondary contact, and the criteria for seafood for human consumption.

1.4 Environmental management approach

Formal monitoring and management at Swanbourne is regulated by the Department of Environment and restricted to a number of in-line monitoring components (Appendix A). However, to maintain the best practice approach applied at other major metropolitan ocean outfalls, the Swanbourne ocean outlet is also monitored under the Perth Long Term Ocean Outlet Monitoring (PLOOM) program, which first commenced in the mid-1990's. The ocean monitoring program is consistent with the approach advocated under the State Government's EQMF, which is applied to Western Australia's coastal waters under EAG 15 (EPA 2015).

1.4.1 Environmental Quality Management Framework (EQMF)

The EQMF is based on:

- identifying **Environmental Values** (EVs) (Table 1.1)
- establishing and spatially defining **Environmental Quality Objectives** (EQOs) that need to be maintained to ensure the associated EVs are protected (Table 1.1)
- monitoring and managing to ensure the EQOs are achieved and/or maintained in the long-term in the areas they have been designated

- establishing **Environmental Quality Criteria** (EQC), which are quantitative benchmarks or 'trigger values' against which monitoring results can be compared.

There are two levels of EQC:

1. **Environmental Quality Guidelines** (EQGs) are quantitative, investigative triggers which, if met, indicate there is a high degree of certainty that the associated EQO has been achieved. If the guideline is not met a more detailed assessment against the EQS is triggered.
2. **Environmental Quality Standards** (EQSs) are management triggers which, if exceeded, signify that the EQO is at risk of not being met and that a management response may be required.

Table 1.1 Environmental Values and Environmental Quality Objectives for the marine waters of Western Australia

Environmental Values	Environmental Quality Objectives
Ecosystem Health (ecological value)	• EQO 1: Maintain ecosystem integrity at a maximum level of ecological protection. • EQO 1: Maintain ecosystem integrity at a high level of ecological protection. • EQO 1: Maintain ecosystem integrity at a moderate level of ecological protection. • EQO 1: Maintain ecosystem integrity at a low level of ecological protection. This means maintaining the structure (e.g. the variety and quantity of life forms) and functions (e.g. the food chains and nutrient cycles) of marine ecosystems to an appropriate level.
Fishing and Aquaculture (social use value)	• EQO 2: Seafood (caught or grown) is of a quality safe for eating. • EQO 3: Water quality is suitable for aquaculture purposes.
Recreation and Aesthetics (social use value)	• EQO 4: Water quality is safe for primary contact recreation (e.g. swimming and diving). • EQO 5: Water quality is safe for secondary contact recreation (e.g. fishing and boating). • EQO 6: Aesthetic values of the marine environment are protected.
Industrial Water Supply (social use value)	• EQO 7: Water quality is suitable for industrial use.
Cultural and Spiritual (social use value)	• EQO 8: Cultural and spiritual values of the marine environment are protected.

Source: EAG (2015)

1.4.2 'Maintenance of Ecosystem Integrity' EQO

The objective of this EQO is to maintain a healthy and diverse ecosystem. There are effectively four EQOs with each applied depending on the designated level of ecological protection: low, moderate, high or maximum (Table 1.2).

Table 1.2 Levels of ecological protection

Level of Ecological Protection	Definition
Low	Allows large changes in abundance and biomass of marine life, biodiversity and rates of ecosystem processes, but only within a confined area.
Moderate	Applied to relatively small areas within inner ports and adjacent to heavy industrial premises where pollution from current and/or historical activities may have compromised a high level of ecological protection.
High	Allows for small measurable changes in the quality of water, sediment and biota, but not to a level that changes ecosystem processes, biodiversity or abundance and biomass of marine life beyond the limits of natural variation.
Maximum	Activities to be managed so that there were no changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota.

In the absence of mandated management zones, a notional low ecological protection area (LEPA) has been established at the Swanbourne outfall, as per the guidance in EAG 15 (EPA 2015). The LEPA occupies the area within a 100 m radius of the diffuser. Waters outside the LEPA are maintained to a high level of ecological protection (HEPA; Figure 1.2).

1.4.3 'Maintenance of Seafood Safe for Human Consumption' EQO

The objective of this EQO is to maintain seafood safe for human consumption (a social value), with the exception of a small area surrounding the ocean outlet where EQO 2 may not apply and seafood may be unsafe to eat. Formal management zones have not been established for the Swanbourne outlet. However, an informal zone has been established at Swanbourne based on observations of microbiological organisms from ten years of ocean monitoring data. The zone represents the area where microbiological organism counts are most likely to exceed the EPA's criteria for seafood safe for human consumption under worst-case conditions.

1.4.4 'Maintenance of Primary and Secondary Contact Recreation' EQOs

The objectives of the primary and secondary contact EQOs are to support swimming and boating activities, respectively. The EQOs apply throughout Perth's coastal waters with the exception of areas around ocean outlets, where water quality may not be suitable for swimming. A formal area where primary contact recreation is not recommended has not been established for the Swanbourne outlet. However, an informal zone has been developed for the Swanbourne outlet encompassing the area containing elevated microbiological concentrations – this was derived from ten years of field data. As the EQO for maintenance of primary contact recreation uses a higher water quality standard than secondary contact recreation, by default it is assumed that if the primary contact criteria are met, then the secondary contact criteria are also met.

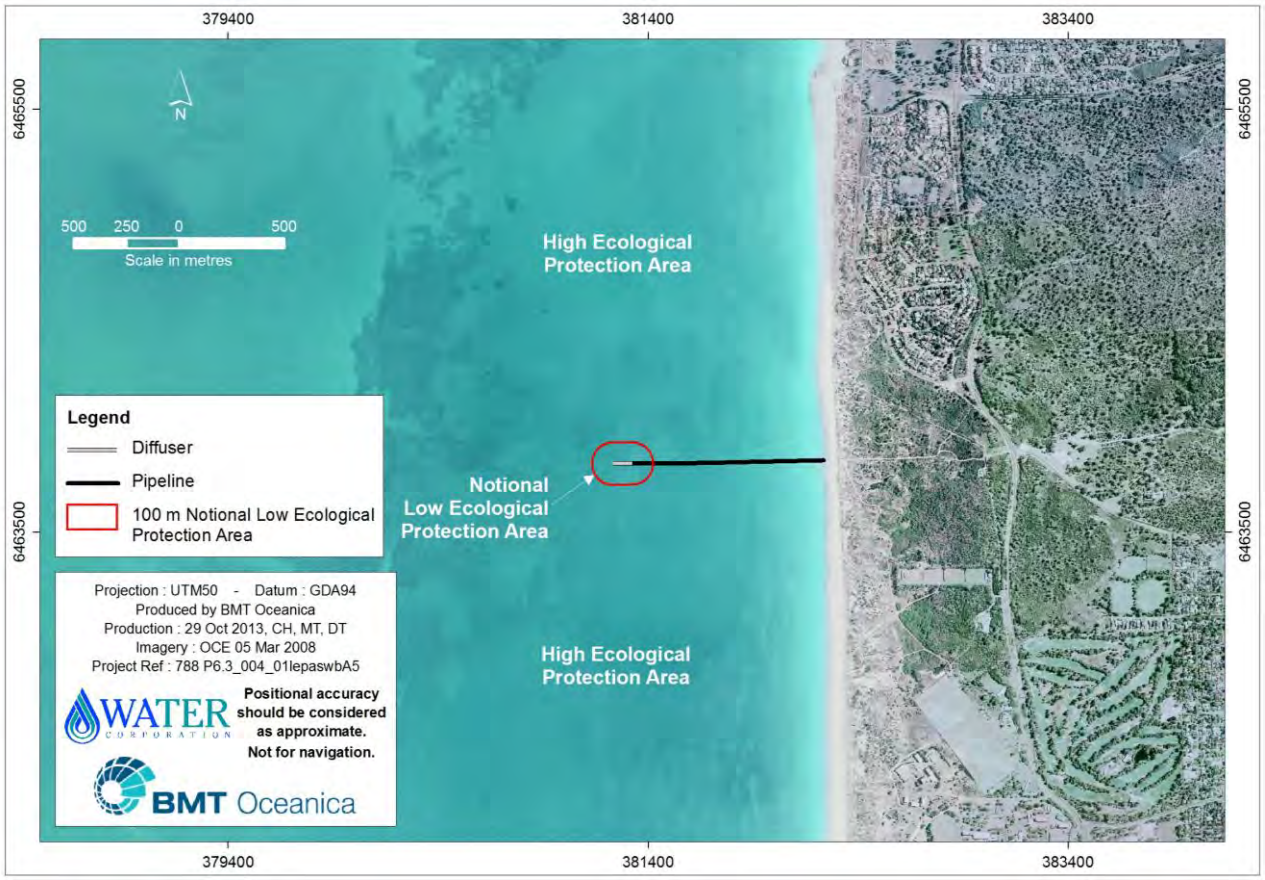


Figure 1.2 Swanbourne ocean outlet notional ecological protection boundaries

2. Maintenance of Ecosystem Integrity

2.1 Environmental Quality Objective

The EQO for the EV 'Ecosystem Health' is aimed at maintaining ecosystem integrity and biodiversity, and ensuring the continued health and productivity of Perth's coastal waters (EPA 2015). The EQC for the EQO 'Maintenance of Ecosystem Integrity' are outlined in Table 2.1.

Table 2.1 Environmental Quality Criteria for the EQO of Maintenance of Ecosystem Integrity (EQO1)[1]

Environmental quality indicator	Environmental Quality Criteria (EQC)[2]	
	Environmental Quality Guideline	Environmental Quality Standard
Toxicants in treated wastewater • ammonia • metals • pesticides • herbicides • other chemicals	**Treated wastewater characterisation – bioaccumulating toxicants** Concentrations of contaminants will not exceed the ANZECC/ARMCANZ (2000) 80% species protection guideline trigger levels for bioaccumulating toxicants in the wastewater stream.	**Sentinel mussel monitoring** The median concentrations of metals that may bioaccumulate (cadmium and mercury) within mussel tissue from sites at the boundary of the low/high ecological protection areas will not exceed the 80th percentile of reference site data.
	Treated wastewater characterisation – non-bioaccumulating toxicants The information on wastewater quality, in conjunction with the results from the initial dilution modelling, will be evaluated to determine whether: The ANZECC/ARMCANZ (2000) 99% species protection guideline trigger levels for toxicants (with the exception of cobalt, where the 95% guideline trigger level will apply), are being achieved at the boundary of the low ecological protection area (LEPA) (i.e. a high level of protection is met beyond a 100 m radius of the diffuser). The total toxicity of the mixture (TTM) for the additive effect of ammonia, copper and zinc, calculated as per ANZECC/ARMCANZ (2000), will not exceed the trigger value of 1.0 (refer to Section 2.2.1). Note that for metals, the assessment is to be based on bioavailable concentrations of metals in the wastewater (i.e. concentrations after filtering through a 0.45 µm filter). If any EQGs are exceeded, assessment against the EQS will commence.	**Whole of effluent toxicity (WET) testing** Undertake the full suite of WET testing of the waste stream in accordance with ANZECC/ARMCANZ (2000) guidelines. The EQS will be exceeded where: $\frac{DALEPA}{DR99\%BurrliOZ} \leq 1$ where *DALEPA* = dilutions achieved at the boundary of the LEPA; *DR99%BurrliOZ* = number dilutions required to achieve the 99% species protection guideline specific to treated wastewater that is calculated with BurrliOZ software using the results of the full suite of WET tests, as per ANZECC/ARMCANZ (2000).
	Whole of effluent toxicity (WET) testing The EQG will be exceeded if following the 1-hour sea urchin test: $\frac{TDA}{DRNOEC} \leq 1.0$ where TDA = Typical Dilutions Achieved (constant based on 100-fold dilution) DRNOEC = number of dilutions required to achieve the no observed effects concentration (NOEC). Breaching the above triggers investigations against the EQS, which would comprise the full suite of WET tests (minimum of five species from four trophic groups).	**Whole of effluent toxicity (WET) testing** As per EQS above.
Receiving water physical-chemical measures • nutrient enrichment • organic enrichment • salinity	**Nutrient enrichment** 1. Ambient value[3] of defined area[4] during non-river flow period[5] not to exceed chlorophyll-a: 80th percentile of reference sites data. 2. Ambient value[3] of defined area[4] during non-river flow period[5] not to exceed light attenuation: 80th percentile of reference sites data.	Not applicable. No suitable EQS available.
	Organic enrichment Ambient value[3] for dissolved oxygen in bottom waters (0–0.5 m above the sediment surface) greater than 90% saturation at any site for a defined period of not more than 6 weeks.	**Organic enrichment** Ambient value[3] for dissolved oxygen in bottom waters (0–0.5 m above the sediment surface) greater than 60% saturation at any site for a defined period of not more than 6 weeks. No deaths of marine organisms resulting from de-oxygenation.
	Salinity Median salinity (0.5 m below the water surface) at an individual site over any period not to deviate beyond the 20th and 80th percentile of natural salinity range over the same period.	**Salinity** No deaths of marine organisms resulting from anthropogenically-sourced salinity stress.

Environmental quality indicator	Environmental Quality Criteria (EQC)[2]	
	Environmental Quality Guideline	Environmental Quality Standard
Receiving water direct biological measures (algal growth potential) • phytoplankton biomass (chlorophyll-a)	**Phytoplankton blooms** 1. Ambient value[3] for phytoplankton biomass measured as chlorophyll-a not to exceed 3 times median chlorophyll-a concentration of reference sites, on any occasion during non-river flow period[5]. 2. Phytoplankton biomass measured as chlorophyll-a at any site does not exceed 3 times median chlorophyll-a concentration of reference sites, on 25% or more occasions during the non-river flow period[5]. If either of these EQGs are exceeded, assessment will proceed against the EQS.	**Phytoplankton blooms** 1. Ambient value[3] for phytoplankton biomass measured as chlorophyll-a not to exceed 3 times median chlorophyll-a concentration of reference sites, on more than one occasion during non-river flow period[5] and in two consecutive years. 2. Phytoplankton biomass measured as chlorophyll-a at any site does not exceed 3 times median chlorophyll-a concentration of reference sites, on 25% or more occasions during the non-river flow period[6] and in two consecutive years.

Notes:
1. Based on the EQC Reference Document for Cockburn Sound (2003–2004) (EPA 2005a).
2. Where there is more than one EQC for an indicator, each one is to be considered individually. If any one of these is exceeded then the guideline or standard for that indicator has not been met.
3. Ambient value = median value of individual sample data for a defined area.
4. Defined area = area to be characterised for environmental quality against pre-determined Environmental Quality Objectives and levels of ecological protection.
5. Non-river flow period = summer period December–March inclusive, when river flows are weak.

2.2 Toxicants in treated wastewater

2.2.1 Comprehensive treated wastewater characterisation (CTWWC)

TWW (final effluent) from the Subiaco WWTP is analysed for a suite of contaminants of concern:

- nutrients (total nitrogen, ammonia, nitrate+nitrite, total phosphorus, orthophosphate)
- microbiological contaminants
- bioavailable metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver and zinc)
- pesticides and herbicides (organophosphate pesticides, organochlorine pesticides, triazine herbicides)
- polyaromatic hydrocarbons
- phthalates
- polychlorinated biphenyls
- benzene, toluene, ethylbenzene, and xylenes
- petroleum hydrocarbons
- surfactants
- dissolved organic carbon.

A 24-hour flow-weighted composite sample was obtained from the Subiaco WWTP on 16 February 2016. The bulk sample was homogenised (agitated), split into individual sample containers and sent to a National Association of Testing Authorities (NATA)-accredited laboratory for analysis. Samples for bioavailable metals were filtered through a 0.45 µm filter prior to analysis (EPA 2005b). Analyses were completed using NATA-accredited methods (Appendix B).

Bioaccumulating toxicants

Concentrations of cadmium and mercury (i.e. bioaccumulating toxicants) in the TWW sample were both below the analytical limit of reporting (<0.1 µg/L; Appendix C), and consequently below their respective 80% species protection guidelines (ANZECC/ARMCANZ 2000), thus meeting the EQG.

Non-bioaccumulating toxicants

Contaminant concentrations after the initial dilution of 1:129 (a conservative estimate of the dilution expected at the LEPA boundary; Appendix D) were below the ANZECC/ARMCANZ (2000) 99% species protection guidelines (Table 2.2; Appendix C), thus meeting the EQG. Results for analytes with relevant trigger values are provided in Table 2.2, while results for analytes without triggers are provided for contextual purposes in Appendix C and Appendix E.

Table 2.2 Toxicants in the Swanbourne TWW stream compared with relevant guideline trigger levels after initial dilution

Toxicant[1]	Swanbourne TWW[2]	TWW value after initial dilution[3]	Trigger[4]
Nutrients (µg/L)			
Ammonia-N	610	6.2	500
Dissolved metals (0.45 µm filtered) (µg/L)			
Cadmium	<0.1	–	36
Chromium[5]	<1.0	–	0.14 (Cr VI)
Copper	7	0.13	0.3
Lead	<1.0	–	2.2
Mercury	<0.1	–	1.4
Nickel	2	0.52	7
Silver	<0.8	–	0.8
Zinc	39	0.45	7
Organophosphate pesticides (µg/L)			
Chlorpyrifos[6]	<0.1	–	0.0005
Organochlorine pesticides (µg/L)			
Endrin	<0.001	–	0.004
Endosulfan sulfate[7]	<0.001	–	0.005
BTEX (µg/L)			
Benzene	<1.0	–	500
Poly aromatic hydrocarbons (µg/L)			
Naphthalene	<0.01	–	50
Benzo(g,h,i)perylene	<0.01	–	50

Notes:
1. Assessment against ANZECC/ARMCANZ (2000) 99% species protection guideline values was undertaken only for those toxicants where trigger levels were available.
2. TWW = treated wastewater.
3. Initial dilution = 1:129 (predicted average value for Swanbourne outlet). Contaminant dilution calculations were not performed (–) on any toxicants where concentrations were below the analytical limit of reporting.
4. The trigger values for marine waters are from Table 3.4.1 in ANZECC/ARMCANZ (2000). The EPA has provided advice that in WA waters where a high level of protection applies, the 99% species protection levels should be used. The bioaccumulating toxicants cadmium and mercury must meet the 80% species protection guidelines at the diffuser (i.e. prior to initial dilution), and therefore a diluted concentration was not calculated.
5. Measured values are total chromium (Cr) – while dissolved Cr in TWW is predominantly Cr III, a conservative approach was taken and assessment is against the Cr VI trigger.
6. Analytical limits for Chlorpyrifos were not low enough to confirm exceedance of, or compliance with, the ANZECC/ARMCANZ (2000) guidelines. Until detection limits required for direct comparison can be attained by commercial laboratories, WET testing will provide a test of the toxicity of the wastewater stream (see Section 2.2.2).
7. Trigger values are for endosulfan, not endosulfan sulfate (Table 3.4.1; ANZECC/ARMCANZ 2000).

Total toxicity of the mixture (TTM)

The potential for cumulative toxic effects on marine organisms is assessed after initial dilution as per ANZECC/ARMCANZ (2000), based on the effects of ammonia, copper and zinc (the three contaminants of concern most likely to exceed their respective guidelines).

$$\text{Total Toxicity of Mixture} = \frac{[\text{ammonia}]}{[\text{Trigger Value}]} + \frac{[\text{copper}]}{[\text{Trigger Value}]} + \frac{[\text{zinc}]}{[\text{Trigger Value}]}$$

The calculated TTM following initial dilution (0.53; Table 2.3), was less than the ANZECC/ARMCANZ (2000) guideline value of 1.0, and thus met the EQG.

Table 2.3 Total toxicity of treated wastewater (TWW) at the edge of the initial mixing zone associated with the Swanbourne ocean outlet

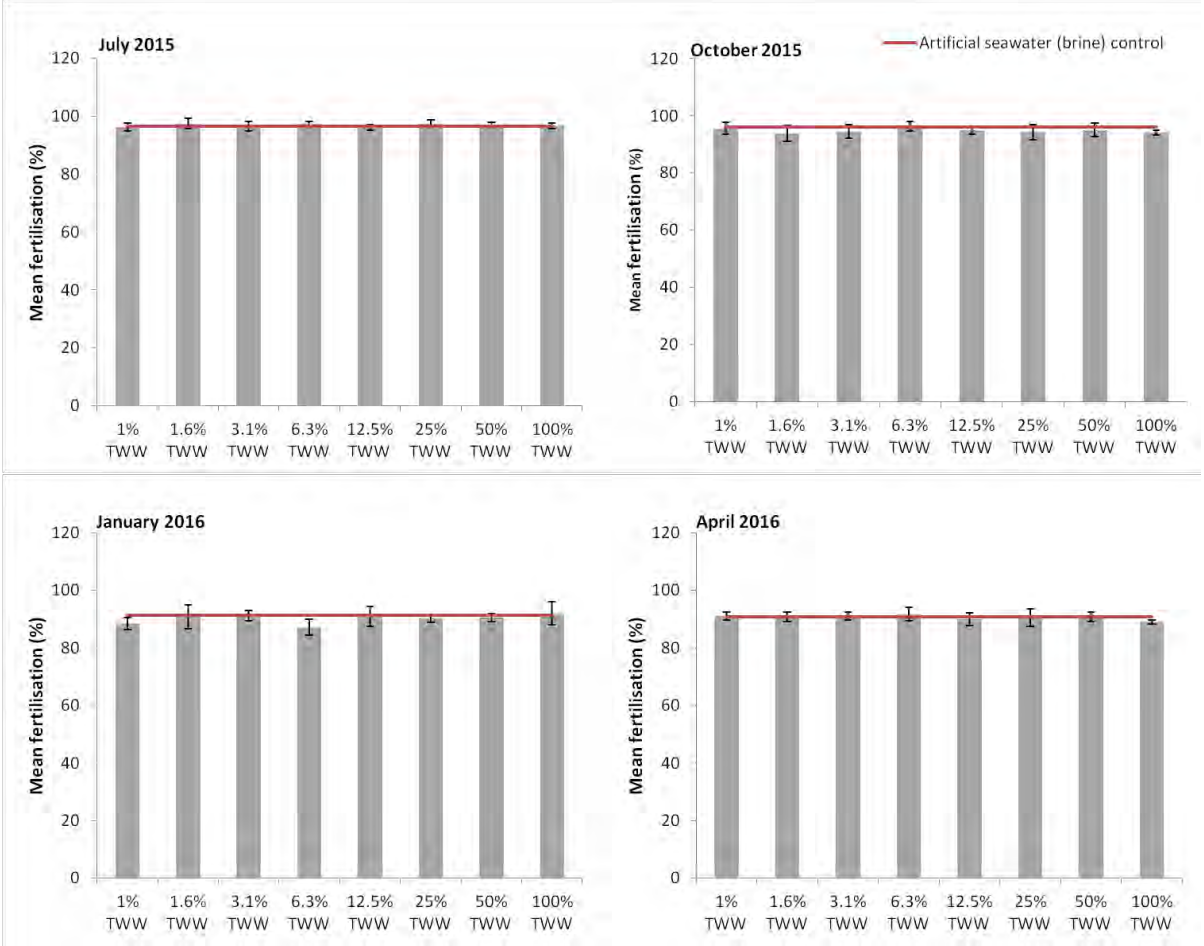
Natural concentrations in Perth's coastal waters (µg/L)			Initial dilution of TWW with seawater	Total toxicity of the mixture (TTM)[2]
Ammonia[1]	Copper[1]	Zinc[1]		
1.5	0.08	0.15	1:129	0.53

Notes:
1. Background concentrations for copper and zinc from McAlpine et al. (2005); Perth marine waters (pp. 19; Table 12). Surface background concentration for ammonia calculated as median of reference site data from 2003–2016 (BMT Oceanica, unpublished data).
2. TTM = [ammonia]/guideline + [copper]/guideline + [zinc]/guideline.

2.2.2 Whole of effluent toxicity (WET) testing

WET testing is useful for assessing toxicity in the absence of reliable guidelines, for toxicants that occur in low concentrations, or where the toxicity effects of contaminants are poorly understood. Fertilisation success in sea urchins (*Heliocidaris tuberculata*) exposed to salt adjusted dilutions (1.0, 1.6, 3.1, 6.3, 12.5, 25, 50 and 100%) of TWW was used to calculate a No Observed Effect Concentration (NOEC; the highest concentration where no significant effect is observed). Further methodological details are provided in Appendix F.

There were no significant differences in fertilisation success between the artificial seawater control and any TWW dilutions of 24-hour flow-weighted composite samples collected in July 2015, October 2015, January 2016 and April 2016 (Figure 2.1; Appendix G). The NOEC was greater than 1% TWW (i.e. ≤100-fold dilution) in all four samples (Table 2.4; Appendix G), and thus the EQG for WET testing was met.



Notes:
1. Error bars are ± 1 standard deviation.
2. Light grey bars represent concentrations of treated wastewater (TWW) at which there is no observed significant effect on fertilisation.

Figure 2.1 Comparison of whole of effluent toxicity TWW dilution results to artificial seawater control

Table 2.4 Calculated parameters from whole of effluent toxicity tests

Indicator	July 2015	October 2015	January 2016	April 2016
NOEC	100%	100%	100%	100%
Dilutions required to meet the NOEC	0	0	0	0
Dilutions require/dilutions achieved	0	0	0	0
≤1	Yes	Yes	Yes	Yes

Notes:
1. NOEC = no observed effect concentration.

2.3 Water quality monitoring – receiving environment

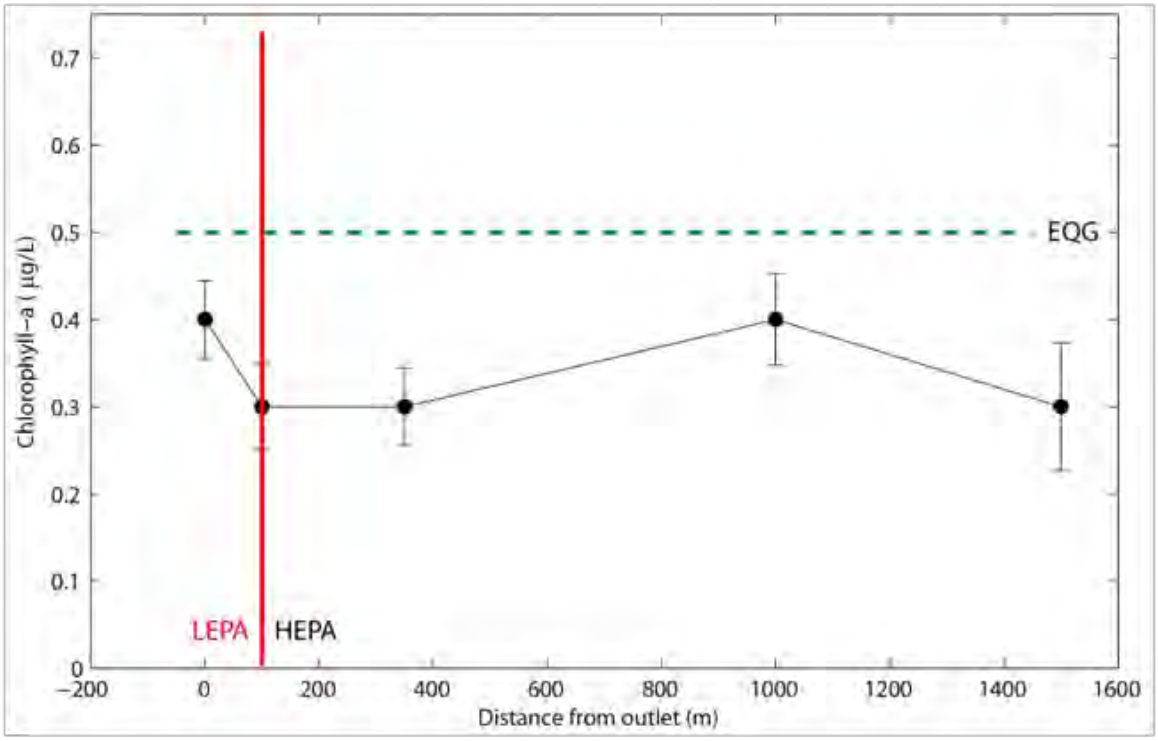
Nutrients, phytoplankton biomass and physical and chemical stressors were monitored along a down-current gradient approximately fortnightly from the beginning of December 2015 to the end of March 2016 (Table 2.5), coinciding with the summer non-river flow period. Refer to Appendix F for full methodological details.

Table 2.5 Water quality monitoring dates near the Swanbourne ocean outlet between December 2015 and March 2016

Sampling day	Date
1	03/12/2015
2	11/12/2015
3	07/01/2016
4	28/01/2016
5	11/02/2016
6	23/02/2016
7	01/03/2016
8	18/03/2016

2.3.1 Nutrient enrichment

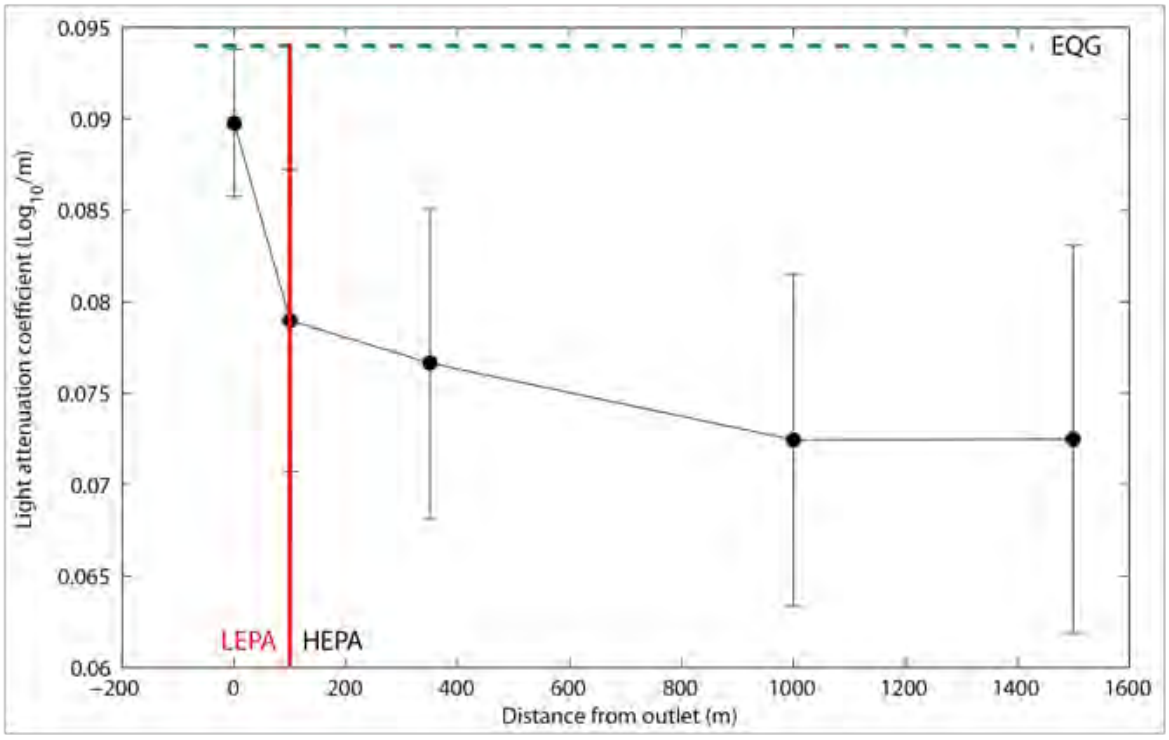
Median chlorophyll-a concentration in the HEPA was 0.3 µg/L and was therefore below the 80th percentile of historical reference site data (0.5 µg/L; Figure 2.2), thus meeting the EQG.



Notes:
1. Error bars represent ±95% confidence intervals.
2. Environmental Quality Guideline (EQG) is the 80th percentile of historical reference site data (0.5 µg/L chlorophyll-a).
3. LEPA = notional low ecological protection area; HEPA = high ecological protection area.
4. Data for each distance were pooled across eight sampling days over December 2015–March 2016.

Figure 2.2 Median chlorophyll-a concentrations obtained at fixed monitoring sites above and down-current of the Swanbourne outlet during the summer monitoring period

Median light attenuation within the HEPA was 0.077 Log_{10}/m and was therefore lower than the 80th percentile of historical reference site data (0.094 Log_{10}/m; Figure 2.3), thus meeting the EQG.

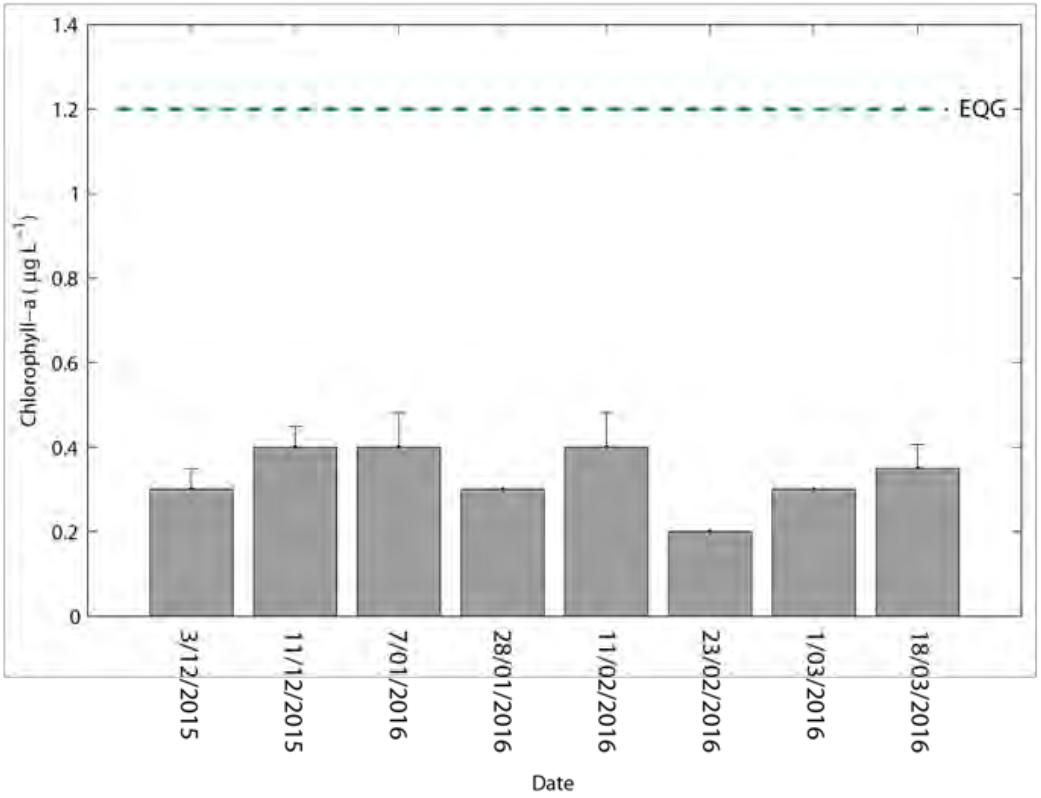


Notes:
1. Error bars represent ±95% confidence intervals.
2. Environmental Quality Guideline (EQG) is the 80th percentile of historical reference site data (0.094 Log_{10}/m).
3. LEPA = notional low ecological protection area; HEPA = high ecological protection area.
4. Data for each distance were pooled across eight sampling days over December 2015–March 2016.

Figure 2.3 Median light attenuation coefficient obtained at fixed distances down-current of the Swanbourne outlet during the summer monitoring period

2.3.2 Phytoplankton blooms

The median chlorophyll-a concentration (0.3 µg/L) calculated from the combined HEPA sites following each sampling event was less than 3 x median of reference sites (1.2 µg/L), thus meeting the first EQG for this indicator. In addition, the median chlorophyll-a concentration at individual sites did not exceed than 3 x median of reference sites on more than 25% of sampling occasions, thus meeting the second EQG for this indicator (Figure 2.4).



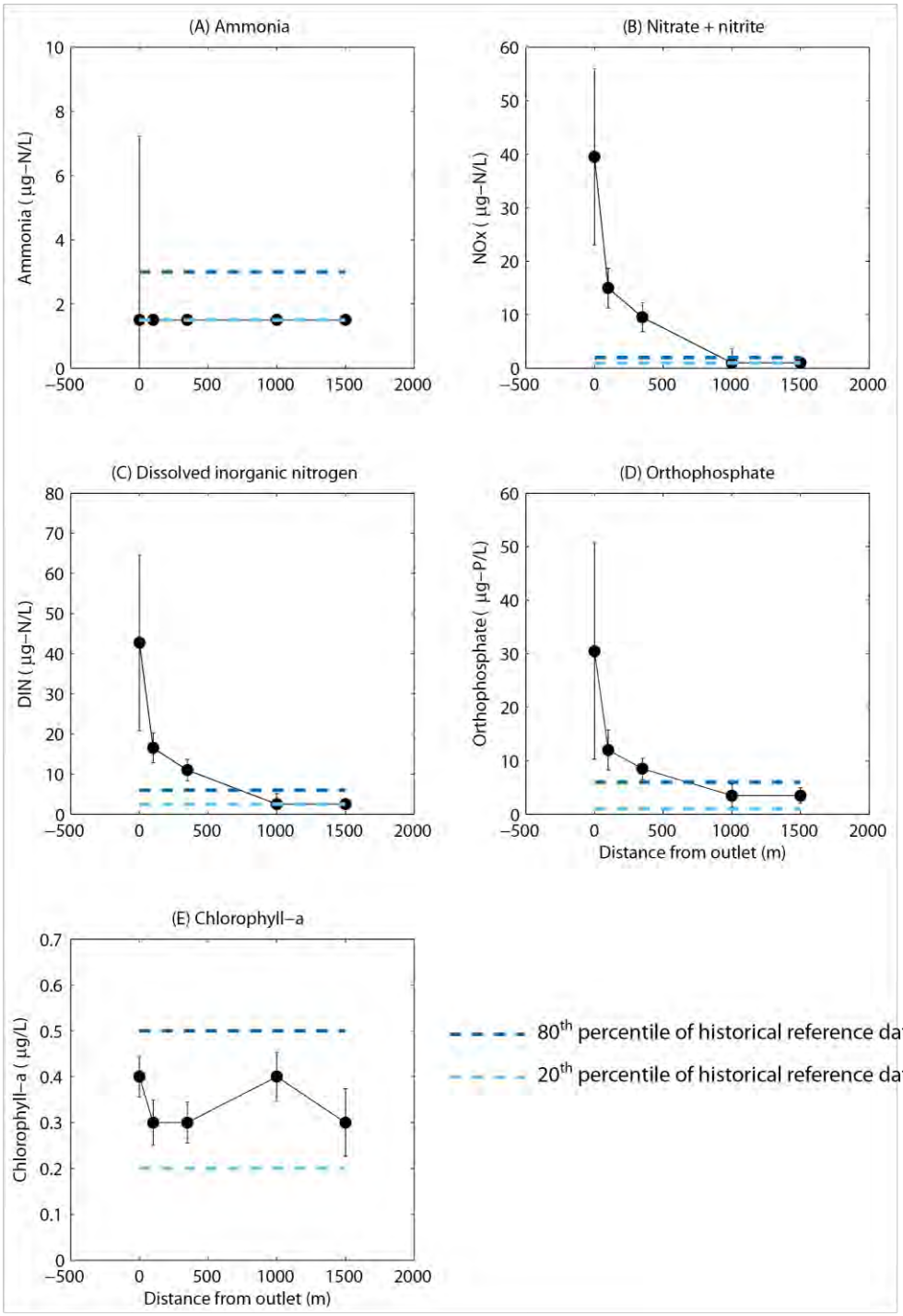
Notes:
1. Error bars represent ±95% confidence intervals.
2. Environmental Quality Guideline (EQG) is 3-times the median chlorophyll-a concentration of reference site data.
3. Values measured at 0 m are not included in the figure or EQG assessment, as the 0 m site is situated directly above the outlet within the notional low ecological protection area (LEPA).
4. Data were pooled across four sites within the high ecological protection area (HEPA).

Figure 2.4 Median phytoplankton biomass during the summer monitoring period, pooling data from fixed sites ≥100 m down-current of the Swanbourne ocean outlet

Additional data – nutrient gradients

The characterisation of nutrient gradients is useful for detecting the plume footprint by determining the distance down-current where nutrient concentrations reach background concentrations. Background levels are considered to be between the 20th and 80th percentile of historical reference site data (dark blue and light blue broken lines, respectively, in Figure 2.5).

Median concentrations of nitrate+nitrite (NO_x) and orthophosphate were elevated above background concentrations at the outlet and for a maximum distance of ~1000 m down-current of the outlet (Figure 2.5B,D). Dissolved inorganic nitrogen was also elevated over the same area (Figure 2.5C) due to the contribution of NO_x to the overall dissolved nitrogen load. The advanced nitrification processes at the Subiaco WWTP converts ammonia to nitrite and then nitrate so median ammonia concentrations were at the limit of detection ≥100 m down-current (Figure 2.5A). Median chlorophyll-a levels were within the 80th percentile of historical reference site data at all of the monitoring sites (Figure 2.5E).



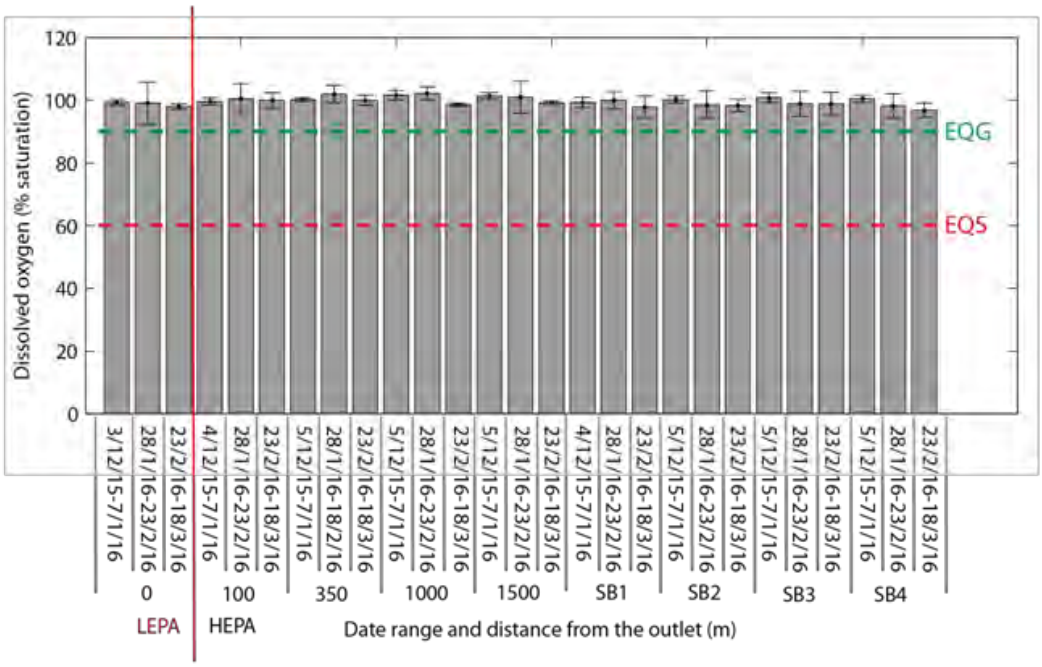
Notes:
1. Error bars represent ± 95% confidence intervals.
2. NOx = nitrate+nitrite; DIN = dissolved inorganic nitrogen.
3. Data for each distance were pooled across eight sampling days over December 2015–March 2016.

Figure 2.5 Median nutrient and chlorophyll-a concentrations obtained at fixed monitoring sites above and down-current of the Swanbourne ocean outlet during the summer monitoring period

2.3.3 Physical-chemical stressors

Dissolved oxygen (DO)

The near-bottom (0–0.5 m) DO concentrations measured on eight occasions between December 2015 and March 2016 at Swanbourne were >90% saturation at all times (Figure 2.6) and similar to near-bottom DO saturation at the four reference sites (SB1–SB4) (Figure 2.6). As the ambient value for DO in bottom waters was >90% saturation over defined periods of ≤6 weeks during the 2015–2016 summer monitoring period, the EQG for organic enrichment was met.

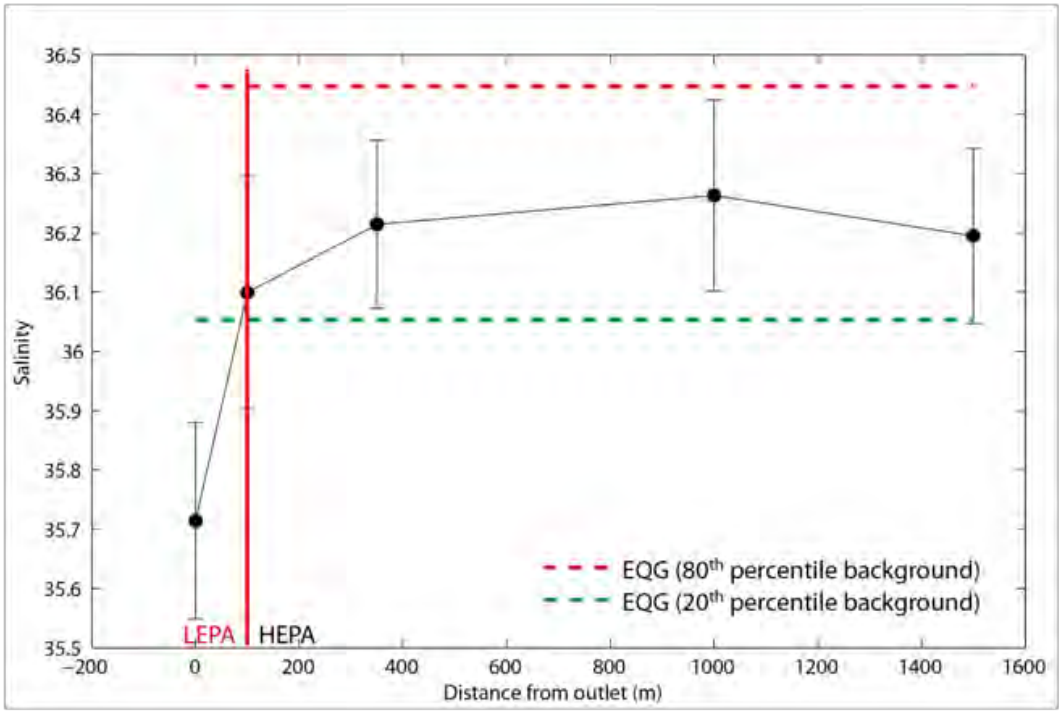


Notes:
1. Error bars represent ±95% confidence intervals.
2. Dissolved oxygen (DO) measured 0–0.5 m above the seabed.
3. Environmental Quality Guideline (EQG) = 90% DO saturation; Environmental Quality Standard (EQS) = 60% DO saturation.
4. LEPA = notional low ecological protection area; HEPA = high ecological protection area.
5. Reference site data (SB1–SB4) are compared against EQG and EQG for contextual purposes only.

Figure 2.6 Median dissolved oxygen for defined periods of ≤6 weeks during the summer monitoring period

Salinity

Median salinity was lowest within the notional LEPA (35.71; directly above the outlet), and was between the 20th and 80th percentile of the natural salinity range within the notional HEPA (at 100, 350, 1000 and 1500 m from the outlet; Figure 2.7). The EQG requires the median salinity not to deviate beyond the 20th and 80th percentile of the natural salinity range at any individual site within the notional HEPA over the summer monitoring period, thus the EQG was met.



Notes:
1. Error bars represent ±95% confidence intervals.
2. Salinity measured 0–0.5 m below the sea surface.
3. EQG = Environmental Quality Guideline.
4. LEPA = notional low ecological protection area; HEPA = high ecological protection area.
5. Data for each distance was pooled across eight sampling occasions over December 2015 to March 2016.

Figure 2.7 Median salinity compared to the 20th and 80th percentile of reference site data during the summer monitoring period

2.4 Monitoring summary

Results of the 2015–2016 monitoring programs revealed no exceedances of EQGs for the EQO 'Maintenance of Ecosystem Integrity'. These results are summarised in Table 2.6.

Table 2.6 Compliance against EQC relevant to the EQO 'Maintenance of Ecosystem Integrity' (EQO1)

Environmental quality indicator		EQC	Comments	Compliance
Toxicants in treated wastewater (TWW)	Bioaccumulating toxicants	EQG	Cadmium and mercury in the undiluted TWW stream were measured at concentrations well below the ANZECC/ARMCANZ (2000) values for 80% species protection	■
	Non-bioaccumulating toxicants and initial dilution		The rate of initial dilution on 16 February 2016 (1:129) was sufficient to reduce contaminant concentrations to values lower than the ANZECC/ARMCANZ (2000) values for 99% species protection	■
	Total toxicity of the mixture (TTM)		The TTM for the additive effect of ammonia, copper and zinc after initial dilution (0.53) was below the ANZECC/ARMCANZ (2000) guideline value of 1.0	■
	Whole of effluent toxicity testing		The lowest NOEC recorded during the reporting period was 100% TWW. No dilution of the TWW was required to achieve this NOEC	■
Nutrient enrichment	Chlorophyll-a	EQG	The overall median chlorophyll-a concentration within the high ecological protection area (HEPA) was lower than the 80th percentile of historical reference site data	■
	Light attenuation coefficient (LAC)		The overall median LAC within the HEPA was lower than the 80th percentile of historical reference site data	■
Phytoplankton blooms	Phytoplankton biomass (measured as chlorophyll-a)	EQG	1. There were no instances where median chlorophyll-a levels in the HEPA exceeded 3-times median of reference sites.	■
			2. No chlorophyll-a samples at any site (and at any time) exceeded 3-times the median of reference sites	■
Physical-chemistry	Organic enrichment	EQG	Dissolved oxygen saturation remained above 90% saturation at all times	■
	Salinity	EQG	Within the HEPA, median salinity was within the 20th and 80th percentile of reference site data	■

Notes:

1. Green (■) symbols indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS), respectively.
2. NOEC = no observed effect concentration; the highest concentration of TWW at which there is no statistically significant observed effect on gamete fertilisation.
3. EQO = Environmental Quality Objective.

3. Maintenance of Seafood for Human Consumption

3.1 Environmental Quality Objective

The EQO for the EV 'Fishing and Aquaculture' is aimed at ensuring seafood is safe for human consumption. The EQC for the EQO 'Maintenance of Seafood for Human Consumption' are outlined in Table 3.1.

Table 3.1 Environmental Quality Criteria for the EQO 'Maintenance of Seafood for Human Consumption' (EQO2)

Environmental quality indicator	Environmental Quality Criteria	
	Environmental Quality Guideline	Environmental Quality Standard
Thermotolerant coliforms (TTC)	Median TTC concentrations at sites at the boundary of the Observed Zone of Influence (OZI) are not to exceed 14 CFU/100 mL, with no more than 10% of the samples exceeding 21 CFU/100 mL as measured using the membrane filtration method.	Median TTC concentrations at sites at the boundary of the OZI not to exceed 70 CFU/100 mL, with no more than 10% of the samples exceeding 85 CFU/100 mL as measured using the membrane filtration method.
Algal biotoxins	Concentrations of potentially toxic algae at sites at the boundary of the OZI not to exceed the WASQAP[1] trigger concentrations for any of the following: • *Alexandrium* spp.[2] (100 cells/L) • *Gymnodinium* spp. (1000 cells/L) • *Karenia* spp.[2] (1000 cells/L) • *Dinophysis* spp.[2] (500 cells/L) • *Dinophysis acuminta* (3000 cells/L) • *Prorocentrum lima* (500 cells/L) • *Psuedo-nitzschia* spp.[2] (250 000 cells/L) • *Gonyaulax* cf. *spinifera* (100 cells/L) • *Protoceratium reticulatum* (*Gonyaulax grindleyi*) (500 cells/L) If this EQG is exceeded, assessment will proceed against the EQS for sentinel mussel tissues.	Toxin concentrations in seafood not to exceed EQS in any sample at the boundary of the OZI[1]: • paralytic shellfish poison (0.8 mg Saxitoxin eq./kg) • diarrhoetic shellfish poison (0.2 mg/kg) • neurotoxic shellfish poison (200 mouse units/kg) • amnesic shellfish poison (domoic acid; 20 mg/kg).

Notes:
1. Western Australian Shellfish Quality Assurance Program (WASQAP) Operations Manual (DoF 2007)
2. As per species list in WASQAP Operations Manual (DoF 2007).

3.2 Microbiological contaminants and algal biotoxins

3.2.1 Thermotolerant coliforms

TTC were sampled eight times over the 2015–2016 summer monitoring period (yielding a total of 40 samples). NHMRC (2008) guidelines and EPA (2005b) suggest that a minimum of 100 samples over the monitoring period are needed for accurate assessment of the EQC. Data from multiple years can be pooled where there are <100 samples provided local pollution conditions have not changed (NHMRC 2008). Assuming conditions have not changed, data collected over three summers (since summer 2013–14) were pooled to yield an adequate sample size (n=120).

The median concentration of TTC derived from the three years of pooled samples was equal to the limit of detection (<10 CFU/100 mL; Table 3.2), thus meeting the EQG criterion for median concentrations (not to exceed 14 CFU/100 mL). TTC did not exceed 21 CFU/100 mL on any occasion over the three sampling periods, meeting the EQG criterion for percentage of samples above 21 CFU/100 mL.

Table 3.2 Median thermotolerant coliform concentration at the fixed monitoring sites for the Swanbourne ocean outlet for 2013–2016 and comparison to the EQC

Sampling period	Median (CFU/100 mL)	Compliance (EQG)
Dec 2013–Mar 2014 Dec 2014–Mar 2015 Dec 2015–Mar 2016 (n=120)	<10	■

Notes:

1. Green symbols (■) indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) and Environmental Quality Standard (EQS), respectively.
2. For site locations and GPS waypoints, see Appendix I.
3. Thermotolerant coliform results below the analytical detection limit (< 10 CFU/100 mL) were halved (= 5 CFU/100 mL) to calculate the median.
4. Environmental Quality Criteria are based on EPA (2005a).

3.2.2 Toxic phytoplankton species

There were no instances where toxic phytoplankton species were present at densities greater than the Western Australian Shellfish Quality Assurance Program (WASQAP; DoF 2007) guideline values (Table 3.3).

Table 3.3 Estimated cell densities of phytoplankton species known to produce toxins

Date	Site[1]	Species	Estimated density (cells/L)	WASQAP guideline[2]	Compliance[3]
03/12/2015	SB23 monitoring	*Pseudo-nitzschia "delicatissima group"*	1008	250 000	■
	SBR2 reference	*Pseudo-nitzschia "delicatissima group"*	504	250 000	■
11/12/2016	SB28 monitoring	*Pseudo-nitzschia "delicatissima group"*	8316	250 000	■
	SBR2 reference	*Pseudo-nitzschia "delicatissima group"*	2268	250 000	■
7/01/2016	SB29 monitoring	No toxic species detected	–	NA	NA
	SBR2 reference	*Pseudo-nitzschia "delicatissima group"*	252	250 000	■
28/01/2016	SB26 monitoring	*Pseudo-nitzschia "delicatissima group"*	2772	250 000	■
	SBR2 reference	*Pseudo-nitzschia "delicatissima group"*	1512	250 000	■
11/02/2016	SB19 monitoring	*Pseudo-nitzschia "delicatissima group"*	1260	250 000	■
	SBR2 reference	*Pseudo-nitzschia "delicatissima group"*	252	250 000	■
23/02/2016	SB28 monitoring	No toxic species detected	–	NA	NA
	SBR2 reference	*Pseudo-nitzschia "delicatissima group"*	504	250 000	■
18/03/2016	SB26 monitoring	*Pseudo-nitzschia "delicatissima group"*	756	250 000	■
	SBR2 reference	*Pseudo-nitzschia "delicatissima group"*	1008	250 000	■

Notes:
1. Samples were analysed for one monitoring site and one reference site per sampling occasion.
2. Western Australian Shellfish Quality Assurance Program (WASQAP; DoF 2007).
3. Green (■) symbols indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS), respectively.
4. For site locations and GPS waypoints, see Appendix I.
5. NA = not applicable.

3.3 Monitoring summary

Results of the 2015–2016 monitoring programs revealed no exceedances of EQGs for the EQO 'Maintenance of Seafood for Human Consumption' (Table 3.4).

Table 3.4 Compliance against EQC relevant to the EQO 'Maintenance of Seafood for Human Consumption'

Environmental quality indicator		Comments	Compliance[1]
Microbiological contaminants	Thermotolerant coliforms (TTC)	The median value for TTC concentrations derived from 120 samples collected over the 2013–2014, 2014–2015 and 2015–2016 sampling seasons was at the limit of detection (<10 CFU/100 mL)[2]	■
		There were no TTC samples that exceeded 21 CFU/100 mL over the 3-season pooled dataset (n=120)	■
Algal biotoxins	Toxic phytoplankton species	Results of the 2015–2016 monitoring program found no instances where toxic phytoplankton species were recorded in excess of WASQAP guideline values (DoF 2007)	■

Note:

1. Green (■) symbols indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) or Environmental Quality Standard (EQS), respectively.
2. TTC results below the analytical detection limit (<10 CFU/mL) were halved (= 5 CFU/mL) to calculate median values.

4. Maintenance of Primary and Secondary Contact Recreation

4.1 Environmental Quality Objective

The EQOs for the EV 'Recreation and Aesthetics' are aimed at ensuring Perth's coastal waters are safe for primary and secondary contact recreation activities such as swimming and boating. The EQC for the EQO 'Maintenance of Primary and Secondary Contact Recreation' are outlined in Table 4.1.

Table 4.1 Environmental Quality Criteria for the EQOs of 'Maintenance of Primary and Secondary Contact Recreation' (EQO4 and EQO5)

Environmental quality indicators	Environmental Quality Criteria	
	Environmental Quality Guideline	**Environmental Quality Standard**
Faecal pathogens	Primary contact: The 95th percentile value of *Enterococci* concentrations taken over the bathing season not to exceed 200 MPN/100 mL, outside the observed zone of influence (OZI) boundary. Secondary contact: The 95th percentile value of *Enterococci* concentrations taken over the bathing season not to exceed 2000 MPN/100 mL, outside the OZI boundary.	Primary contact: The 95th percentile value of *Enterococci* concentrations taken over the bathing season not to exceed 500 MPN/100 mL, outside the OZI boundary. Secondary contact: The 95th percentile value of *Enterococci* concentrations taken over the bathing season not to exceed 5000 MPN/100 mL, outside the OZI boundary.
Algal biotoxins	Median total phytoplankton cell concentration for the area of concern (either from one sampling run or from a single site over agreed period of time) should not exceed 15 000 cells/mL. or There should be no reports of skin or eye irritation or potential algal poisoning in swimmers considered by a medical practitioner as potentially resulting from toxic algae when less than 15 000 cells/mL is present in the water column.	There should be no confirmed incidences (by the Department of Health) of skin or eye irritation caused by toxic algae, or of algal poisoning in recreational users.

4.2 Microbiological contaminants and algal biotoxins

4.2.1 Faecal streptococci (*Enterococci* spp.)

Samples were collected eight times over the 2015–2016 summer monitoring period (yielding a total of 40 samples). NHMRC (2008) guidelines and EPA (2005b) suggest that a minimum of 100 samples over the monitoring period are needed for accurate assessment of the EQC. Data from multiple years can be pooled where there are less than 100 samples provided local pollution conditions have changed (NHMRC 2008). Assuming conditions have not changed data from the past three summers were pooled to yield an adequate sample size (n=120).

The 95th percentile of *Enterococci* spp. concentrations based on 120 samples was 10 MPN/100 mL (Table 4.2), thus meeting the EQG for both primary and secondary contact recreation (200 and 2000 MPN/100 mL, respectively).

Table 4.2 The 95th percentile of *Enterococci* spp. concentrations at the boundary of the observed zone of influence for the Swanbourne ocean outlet and comparison to the EQC

Sampling period	95th percentile[1] (MPN/100 mL)	Compliance[2]	
		Primary contact	Secondary contact
Dec 2013–Mar 2014 Dec 2014–Mar 2015 Dec 2015–Mar 2016 (n=120)	10	■	■

Notes:
1. *Enterococci* spp. values below the analytical detection limit (< 10 MPN/100 mL) were halved (= 5 MPN/100 mL) to calculate the 95th percentile.
2. Green symbols (■) indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) and Environmental Quality Standard (EQS), respectively.
3. For site locations and GPS waypoints, see and Appendix I.
4. Environmental Quality Criteria (EQC) based on EPA (2005a) water quality guidelines for recreation waters.

4.2.2 Phytoplankton cell concentrations

Median phytoplankton cell density was 24.4 cells/mL (Table 4.3), thus meeting the EQG of ≤15 000 cells/mL.

Table 4.3 Estimated phytoplankton total cell densities collected at one of the fixed monitoring sites for contact recreation down-current of the Swanbourne outlet

Date	Site	Total density (cells/mL)	Compliance
03/12/2015	SB7	132.3	
11/12/2015	SB11	583.4	
07/01/2016	SB13	153.7	
28/01/2016	SB9	26.7	■
11/02/2016	SB5	18.9	
23/02/2016	SB11	8.1	
01/03/2016	SB7	22.2	
18/03/2016	SB9	17.1	
	Median (all data)	24.4	■

Notes:
1. Green symbols (■) indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) and Environmental Quality Standard (EQS), respectively.
2. For site locations and GPS waypoints, see Appendix I.

4.3 Monitoring summary

Results of the 2015–2016 monitoring programs revealed no exceedances of EQGs for the EQO 'Maintenance of Primary and Secondary Contact Recreation' (Table 4.4).

Table 4.4 Compliance against EQC relevant to the EQO 'Maintenance of Primary and Secondary Contact Recreation'

Environmental Quality Indicator		Comments	EQC	Compliance
Faecal streptococci	*Enterococci* spp.	The 95th percentile of *Enterococci* spp. concentrations was 10 MPN/100 mL	EQG (primary contact)	■
			EQG (secondary contact)	■
Algal biotoxins	Phytoplankton (cell concentration)	The median total phytoplankton cell concentration was 24.4 cells/mL	EQG	■

Note:

1. Green symbols (■) indicate the Environmental Quality Criteria (EQC) were met; amber (■) and red (■) symbols represent an exceedance of the Environmental Quality Guideline (EQG) and Environmental Quality Standard (EQS), respectively.

References

ANZECC/ARMCANZ (2000) National Water Quality Management Strategy: Paper No 4 – Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1 – The Guidelines (Chapters 1–7). Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, Australian Capital Territory, October 2000

BMT Oceanica (2015) Perth Long Term Ocean Outlet Monitoring (PLOOM) Program: 2015 Summer Water Quality Survey – Ocean Reef: 3 February 2015, Swanbourne: 20 January 2015, Sepia Depression: 17 February 2015. Prepared for Water Corporation by BMT Oceanica Pty Ltd, Report No. 1120_006/2_RevB, Perth, Western Australia, June 2015

DoF (2007) Western Australian Shellfish Quality Assurance Program (WASQAP) Operations Manual. Department of Fisheries, Perth, Western Australia

EPA (2005a) Environmental Quality Criteria Reference Document for Cockburn Sound (2003–2004) – A supporting document to the State Environmental (Cockburn Sound) Policy 2005. Environmental Protection Authority, Report No. 20, Perth, Western Australia

EPA (2005b) Manual of Standard Operating Procedures – For Environmental Monitoring against the Cockburn Sound Environmental Quality Criteria (2003 – 2004) – A supporting document to the State Environmental (Cockburn Sound) Policy 2005. Environmental Protection Authority, Report No. 21, Perth, Western Australia

EPA (2015) Environmental Assessment Guideline for Protecting the Quality of Western Australia's Marine Environment. Environmental Protection Authority, Report No. EAG 15, Perth, Western Australia, March 2015

McAlpine KW, Wenziker KJ, Apte SC, Masini RJ (2005) Background quality for coastal marine waters of Perth, Western Australia. Department of Environment, Report No. 117, Perth, Western Australia

NHMRC (2008) Guidelines for Managing Risks in Recreational Water. National Health and Medical Research Council, Canberra, Australian Capital Territory

Appendices on CD

Appendix E – National Measurement Institute Laboratory results

Appendix G – Ecotox Australasia Laboratory results

Appendix H – Marine and Freshwater Research Laboratory results

Appendix J – PathWest Microbiological Laboratory results

Appendix K – Dalcon Environmental Laboratory results

Appendices listed above are available on CD by contacting BMT Oceanica Pty Ltd

Appendix A – Subiaco wastewater treatment plant Licence conditions

Government of **Western Australia**
Department of **Environment Regulation**

Your ref L4726/1991/15
Our ref DEC 794-02
Enquiries Bhabesh Das
Phone 93337521
Fax 93337550
Email bhabesh.das@der.wa.gov.au

Gordon Groth
Environmental Operations Manager
Water Corporation
629 Newcastle Street
LEEDERVILLE WA 6007

Dear Mr Groth

***ENVIRONMENTAL PROTECTION ACT 1986*: LICENCE GRANTED**
Premises: Subiaco Wastewater Treatment Plant
Lot 3150 on Plan 149501, Lot 5286 on Plan 162620 and Lot 6815 on Plan 166929
Lemnos Street, SHENTON PARK WA 6008
Licence Number: L4726/1991/15

A licence under the *Environmental Protection Act 1986* (the Act) has been granted for the above premises. The Department of Environment Regulation will advertise the issuing of this licence in the public notices section of *The West Australian* newspaper.

The licence includes attached conditions. Under section 58(1) of the Act, it is an offence to contravene a condition of a licence. This offence carries a penalty of up to $125,000 and a daily penalty of up to $25,000.

In accordance with section 102(1)(c) of the Act, you have 21 days to appeal the conditions of the licence. Under section 102(3)(a) of the Act, any other person may also appeal the conditions of the licence. To lodge an appeal contact the Office of the Appeals Convenor on 6467 5190 or by email at admin@appealsconvenor.wa.gov.au.

Where a licence is issued for more than one year it requires payment of an annual fee and will cease to have effect if the fee is unpaid. It is the occupier's responsibility to lodge a fee application and pay the annual fee in sufficient time to avoid incurring a late payment fee and for processing to be completed before the licence anniversary date.

If you have any queries regarding the above information, please contact Dr Bhabesh Das on 93337521.

Yours sincerely

Kerry Laszig
Officer delegated under section 20
of the *Environmental Protection Act 1986*

30 October 2014

Government of **Western Australia**
Department of **Environment Regulation**

Licence

Environmental Protection Act 1986, Part V

Licensee: **Water Corporation**

Licence: **L4726/1991/15**

Registered office: 629 Newcastle Street
LEEDERVILLE WA 6007

Premises address: Subiaco Wastewater Treatment Plant
Lemnos Street
SHENTON PARK WA 6008
Being Lot 3150 on Plan 149501, Lot 5286 on Plan 162620 and Lot 6815 on Plan 166929 as depicted in Schedule 1.

Issue Date: Thursday, 30 October 2014

Commencement date: Saturday, 1 November 2014

Expiry date: Tuesday, 31 October 2017

Prescribed Premises Category
Schedule 1 of the *Environmental Protection Regulations 1987*

Category number	Category description	Category production or design capacity	Approved Premises production or design capacity
54	Sewage facility premises – (a) on which sewage is treated (excluding septic tanks); or (b) from which treated sewage is discharged onto land or into waters.	100 cubic metres or more per day	61,400 cubic metres per day – no more than 20,000 tonnes per annual period shall be liquid waste
61	Liquid waste facility: premises on which liquid waste produced on others premises (other than sewage waste) is stored, reprocessed, treated or irrigated.	100 tonnes or more per year	

Conditions
This Licence is subject to the conditions set out in the attached pages.

.....
Officer delegated under section 20
of the *Environmental Protection Act 1986*

Contents

Introduction

This Introduction is not part of the Licence conditions.

DER's industry licensing role
The Department of Environment Regulation (DER) is a government department for the state of Western Australia in the portfolio of the Minister for Environment. DER's purpose is to advise on and implement strategies for a healthy environment for the benefit of all current and future Western Australians.

DER has responsibilities under Part V of the *Environmental Protection Act 1986* (the Act) for the licensing of prescribed premises. Through this process DER works with the business owners, community, consultants, industry and other representatives to prevent, control and abate pollution and environmental harm to conserve and protect the environment. DER also monitors and audits compliance with works approvals and licence conditions, takes enforcement action as appropriate and develops and implement licensing and industry regulation policy.

Licence requirements
This licence is issued under Part V of the Act. Conditions contained within the licence relate to the prevention, reduction or control of emissions and discharges to the environment and to the monitoring and reporting of them.

Where other statutory instruments impose obligations on the Premises/Licensee the intention is not to replicate them in the licence conditions. You should therefore ensure that you are aware of all your statutory obligations under the Act and any other statutory instrument. Legislation can be accessed through the State Law Publisher website using the following link:
http://www.slp.wa.gov.au/legislation/statutes.nsf/default.html

For your Premises relevant statutory instruments include but are not limited to obligations under the:

- *Environmental Protection (Unauthorised Discharges) Regulations 2004* – these Regulations make it an offence to discharge certain materials such as contaminated stormwater into the environment other than in the circumstances set out in the Regulations.
- *Environmental Protection (Controlled Waste) Regulations 2004* - these Regulations place obligations on you if you produce, accept, transport or dispose of controlled waste.
- *Environmental Protection (Noise) Regulations 1997* – these Regulations require noise emissions from the Premises to comply with the assigned noise levels set out in the Regulations.

You must comply with your licence. Non-compliance with your licence is an offence and strict penalties exist for those who do not comply.

Licence holders are also reminded of the requirements of section 53 of the Act which places restrictions on making certain changes to prescribed premises unless the changes are in accordance with a works approval, licence, closure notice or environmental protection notice.

Other Guidelines which you should be aware of include:

- *Western Australian Guidelines for Biosolids Management*, Department of Environment and Conservation, December 2012 (as amended from time to time).

Licence Fees
If you have a licence that is issued for more than one year, you are required to pay an annual licence fee prior to the anniversary date of issue of your licence. Non payment of annual licence fees will result in your licence ceasing to have effect meaning that it will no longer be valid and you will need to apply for a new licence for your Premises.

Ministerial conditions
If your Premises has been assessed under Part IV of the Act you may have had conditions imposed by the Minister for Environment. You are required to comply with any conditions imposed by the Minister.

Premises description and Licence summary
The operations at Water Corporation's Subiaco Wastewater Treatment Plant include:

- the treatment of domestic and commercial sewage via an activated sludge treatment plant which treats the wastewater to a secondary standard;
- reuse of treated wastewater as process water and for landscape irrigation;
- reuse of treated wastewater at McGillivray Oval for landscape irrigation;
- discharge of surplus treated wastewater to the ocean via an ocean outlet located off Swanbourne Beach; and
- treatment and storage of sewage sludge on-site within sludge treatment and storage tanks.

The main potential emissions from the site are discharges of treated wastewater to water and fugitive emissions in the form of odour.

Discharges of treated wastewater to water are managed by treating wastewater to a defined water quality level and undertaking compliance monitoring prior to discharge.

Odour is managed on-site through scrubbing combined odours from the influent channel, pre-treatment building, primary treatment and sludge treatment in the primary odour scrubbers at the odour control facility. Gas extracted from the secondary aeration tanks is combined with the air discharged from the primary scrubbers and scrubbed in the two odour-guard scrubbers. The odour control system is currently monitored by an external service provider. Tests for temperature, air flow rates and H2S concentrations are conducted on a quarterly basis.

This Licence is the successor to licence L4726/1991/14 and the existing licence has been converted to a new format REFIRE licence. This does not alter any emissions or discharges from the premises.

The licences issued for the Premises since 20/10/2003 are:

Instrument log		
Instrument	**Issued**	**Description**
L4726/1991/7	27/09/2002	Licence re-issue
L4726/1991/8	20/10/2003	Licence re-issue
L4726/1991/9	27/09/2004	Licence re-issue
L4726/1991/10	31/10/2005	Licence re-issue

L4726/1991/11	27/10/2006	Licence re-issue
L4726/1991/12	26/10/2007	Licence re-issue
L4726/1991/13	31/10/2008	Licence re-issue
L4726/1991/14	13/10/2011	Licence re-issue
L4726/1991/15	30/10/2014	Licence re-issue – conversion to REFIRE format

Severance

It is the intent of these Licence conditions that they shall operate so that, if a condition or a part of a condition is beyond the power of this Licence to impose, or is otherwise *ultra vires* or invalid, that condition or part of a condition shall be severed and the remainder of these conditions shall nevertheless be valid to the extent that they are within the power of this Licence to impose and are not otherwise *ultra vires* or invalid.

END OF INTRODUCTION

Licence conditions

1 General

1.1 Interpretation

1.1.1 In the Licence, definitions from the *Environmental Protection Act 1986* apply unless the contrary intention appears.

1.1.2 For the purposes of this Licence, unless the contrary intention appears:

'Act' means the *Environmental Protection Act 1986;*

'annual period' means the inclusive period from 1 July until 30 June in the following year;

'AS/NZS 2031' means the Australian Standard AS/NZS 2031 *Selection of containers and preservation of water samples for microbiological analysis;*

'AS/NZS 5667.1' means the Australian Standard AS/NZS 5667.1 *Water Quality – Sampling – Guidance of the Design of sampling programs, sampling techniques and the preservation and handling of samples;*

'AS/NZS 5667.10' means the Australian Standard AS/NZS 5667.10 *Water Quality – Sampling – Guidance on sampling of waste waters;*

'averaging period' means the time over which a limit or target is measured or a monitoring result is obtained;

'CEO' means Chief Executive Officer of the Department of Environment Regulation;

'CEO' for the purpose of correspondence means;

Manager Licensing (Greater Swan)
Department of Environment Regulation
Locked Bag 33
CLOISTERS SQUARE WA 6850
Telephone: (08) 9333 7510
Facsimile: (08) 9333 7550
Email: grswanbooragoon@der.wa.gov.au;

'CEMS' means continuous emissions monitoring system;

'CEMS Code' means the current version of the Continuous Emission Monitoring System (CEMS) Code for Stationary Source Air Emissions, Department of Environment & Conservation, Government of Western Australia;

'cfu/100 mL' means colony forming units per 100 millilitres;

'code of practice for the storage and handling of dangerous goods' means the document titled "Storage and handling of dangerous goods: Code of Practice" published by the Department of Mines and Petroleum, as amended from time to time;

'controlled waste' has the definition in *Environmental Protection (Controlled Waste) Regulations 2004;*

'covers' means metallic or non-metallic covers used to cover the pre-treatment, primary treatment and secondary aeration areas of the treatment plant;

'dangerous goods' has the meaning defined in the *Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007;*

'environmentally hazardous material' means material (either solid or liquid raw materials, materials in the process of manufacture, manufactured products, products used in the manufacturing process, by-products and waste) which if discharged into the environment from or within the premises may cause pollution or environmental harm. Note: Environmentally hazardous materials include dangerous goods where they are stored in quantities below placard quantities. The storage of dangerous goods above placard quantities is regulated by the Department of Mines and Petroleum;

'fugitive emissions' means all emissions not arising from point sources identified in Sections 2.2, 2.3, 2.4 and 2.5;

'Geobag' means a geotextile dewatering bag that allows solids to dewater over time while containing the solid component.

'hardstand' means a surface with a permeability of 10^{-9} metres/second or less;

'Leachate' means liquid released by or water that has percolated through waste and which contains some of its constituents;

'Licence' means this Licence numbered L4726/1991/15 and issued under the *Environmental Protection Act 1986;*

'Licensee' means the person or organisation named as Licensee on page 1 of the Licence;

'NATA' means the National Association of Testing Authorities, Australia;

'NATA accredited' means in relation to the analysis of a sample that the laboratory is NATA accredited for the specified analysis at the time of the analysis;

'odour boundary' means the outer boundary of odour modelled at 5 odour units (OU) at 99.9 percentile 1 hour averaging as depicted on the Map of Odour Boundary in Schedule 1;

'Premises' means the area defined in the Premises Map in Schedule 1 and listed as the Premises address on page 1 of the Licence;

'**Process equipment**' means any wastewater or sludge containment infrastructure or wastewater treatment vessel;

'quarterly' means the four inclusive periods from 1 July to 30 September, 1 October to 31 December and 1 January to 31 March and 1 April to 30 June in the following year.

'Schedule 1' means Schedule 1 of this Licence unless otherwise stated;

'Schedule 2' means Schedule 2 of this Licence unless otherwise stated;

'six-monthly' means the two inclusive periods from 1 July to 30 December and 1 January to 30 June in the following year;

'spot sample' means a discrete sample representative at the time and place at which the sample is taken;

'STP, dry' means standard temperature and pressure (0°C and 101.325 kilopascals); dry;

'Subiaco Main Drain' means Subiaco Main Drain Outlet extending approximately 50 metres off the shore as depicted on the Map of Perth Main Drain and Swanbourne Ocean Outlet Landline in Schedule 1;

'Swanbourne Ocean Outlet' means Swanbourne Ocean Outlet extending 1.1 kilometres off the shore as depicted on the Map of Perth Main Drain and Swanbourne Ocean Outlet Landline in Schedule 1;

'Waste Code' means the Waste Code assigned to a type of controlled waste for purposes of waste tracking and reporting as specified in the Department of Environment Regulation "Controlled Waste Category List" (July 2014), as amended from time to time;

'wastewater treatment vessels' means any vessel or tank containment infrastructure associated with the treatment of wastewater and includes, but not limited to oxidation ditches and clarifiers.

'USEPA' means United States (of America) Environmental Protection Agency;

'usual working day' means 0800 – 1700 hours, Monday to Friday excluding public holidays in Western Australia;

1.1.3 Any reference to an Australian or other standard in the Licence means the relevant parts of the standard in force from time to time during the term of this Licence.

1.1.4 Any reference to a guideline or code of practice in the Licence means the version of that guideline or code of practice in force from time to time, and shall include any amendments or replacements to that guideline or code of practice made during the term of this Licence.

1.2 General conditions

1.2.1 Nothing in the Licence shall be taken to authorise any emission that is not mentioned in the Licence, where the emission amounts to:
(a) pollution;
(b) unreasonable emission;
(c) discharge of waste in circumstances likely to cause pollution; or
(d) being contrary to any written law.

1.2.2 The Licensee shall maintain all pollution control and monitoring equipment to the manufacturer's specification or any relevant and effective internal management system.

1.2.3 The Licensee, except where storage is prescribed in section 1.3, shall ensure that environmentally hazardous substances are stored in accordance with the Code of Practice for the Storage of dangerous goods.

1.2.4 The Licensee shall immediately recover, or remove and dispose of spills of environmentally hazardous materials outside an engineered containment system.

1.3 Premises operation

1.3.1 The Licensee shall record and investigate the exceedance of any descriptive or numerical limit, and/or target in this section.

1.3.2 The Licensee shall only allow waste to be accepted on to the Premises if:
(a) it is of a type listed in Table 1.3.1; and
(b) the quantity accepted is below any limit listed in Table 1.3.1; and
(c) it meets any specification listed in Table 1.3.1

Table 1.3.1: Waste acceptance

Waste	Waste Code	Quantity Limit	Specification[1]
Putrescible and Organic wastes			
Sewage	N/A	61,400 m^3/day (average per year)	Accepted through sewer inflow(s) only
Septage wastes (Sewage) – domestic wastes from apparatus for the treatment of sewage	K210	20,000 t/annual period	Tankered into the premises and discharged in the pre-treatment area Controlled Waste Inlet Port via an enclosed pipeline. Tankered into the premises and discharged via the Pump Station receivable point.

1.3.3 The Licensee shall ensure that the wastes accepted onto the Premises are only subjected to the process(es) set out in Table 1.3.2 and in accordance with any process requirements described in that table.

Table 1.3.2: Waste processing

Waste type	Process	Process requirements
Sewage	Screening, grit removal, disinfection and filtration. And Physical, biological and chemical treatment. **Preliminary treatment** • Screening and Grit removal **Primary treatment** • Primary Sedimentation tanks **Secondary treatment** • Aeration tanks and secondary sedimentation tanks **Tertiary treatment and disinfection** • Filtration and chlorination	Treatment of sewage and septage waste shall be targeted at or below the assessed treatment capacity of 61,400 m^3/day – no more than 20,000 tonnes per annual period shall be liquid waste.
Septage wastes (Sewage) – domestic wastes from apparatus for the treatment of sewage		
Sewage sludge and Waste activated sludge	Sludge treatment and storage	None specified

1.3.4 The Licensee shall ensure that material is only stored and/or treated within vessels or compounds provided with the infrastructure detailed in Table 1.3.3.

Table 1.3.3: Containment infrastructure

Storage vessel or compound	Material	Requirements
Inlet/preliminary works: Mechanical Step Screens and Grit Removal Tanks	Screenings and Grit	Recovered screenings and grit to be stored in a sealed bin which is stored within a bunded hardstand area or a hardstand area that is graded to a collection drain which returns sludge leachate to the start of the treatment process.
Primary Sedimentation Tanks (PST 7-10)	Wastewater	Ensure that the covers on the primary and aeration tank areas of the plant are kept in place at all times except when removal is required for maintenance operations or during emergency situations.
Aeration Treatment (tanks 1-11)		
Secondary Sedimentation Tanks (SST 1-12)		None specified
Sludge blending tanks (SBT 1-2)	Sludge and leachate	Returns sludge leachate to the start of the treatment process.
Lime amended Biosolids Storage Silos (Silo 1 – Silo 6)	Lime amended biosolids	None specified

1.3.5 The Licensee shall manage the wastewater treatment tanks such that:
(a) overtopping of the tanks does not occur; and
(b) stormwater runoff is prevented from entering the tanks; and
(c) there is no discernible seepage loss from the tanks; and
(d) vegetation and floating debris (emergent or otherwise) is prevented from growing or accumulating in the tanks.

1.3.6 The Licensee shall manage the irrigation of treated wastewater such that:
(a) no irrigation generated run-off, spray drift or discharge occurs beyond the boundary of the defined irrigation area(s); and
(b) treated wastewater is evenly distributed over the irrigation area; and
(c) no soil erosion occurs; and
(d) irrigation does not occur on land that is waterlogged; and
(e) vegetation cover is maintained over the irrigation area.

2 Emissions

2.1 General

2.1.1 The Licensee shall record and investigate the exceedance of any descriptive or numerical limit or target specified in any part of section 2 of this Licence.

2.2 Point source emissions to air

2.2.1 The Licensee shall ensure that where waste is emitted to air from the emission points in Table 2.2.1 and identified on the Map of Plant Infrastructure in Schedule 1 it is done so in accordance with the conditions of this Licence.

Table 2.2.1: Emission points to air

Emission point reference	Emission Point reference on Map of plant infrastructure	Emission point height (m)	Source, including any abatement
S9 (Process control table)	Chemical Scrubber Stack	50	Stack via chemical scrubbing system

2.2.2 The Licensee shall not cause or allow point source emissions to emissions to air greater than the limits listed in Table 2.2.2.

Table 2.2.2: Point source emission limits to air

Emission point reference	Parameter	Limit (including units)[1]	Averaging period
S9 (Process control table)	Hydrogen Sulphide	5 mg/m^3 at STP dry	N/A
		0.14g/s at STP dry	

2.2.3 The licensee shall maintain a log of all CEMS calibration curve correlations and make this log available on request.

2.3 Point source emissions to surface water

2.3.1 The Licensee shall ensure that where waste is emitted to surface water from the emission points in Table 2.3.1 and identified on the Map of Perth Main Drain and Swanbourne Ocean Outlet Landline in Schedule 1 it is done so in accordance with the conditions of this Licence.

Table 2.3.1: Emission points to surface water

Emission point reference	Emission point reference on Map of Perth Main Drain and Swanbourne Ocean Outlet Landline	Description	Source including abatement
Swanbourne Ocean Outlet map	Swanbourne Ocean Outlet	Discharge of treated wastewater via the Swanbourne Ocean Outlet extending 1.1 kilometres offshore	Treated wastewater

Perth Main Drain Map	Perth Main Drain (via emergency overflow drain)	Discharge of treated wastewater during unforeseen pump station failures	Treated wastewater

2.3.2 The Licensee shall not cause or allow point source emissions to surface water greater than the limits listed in Table 2.3.2.

Table 2.3.2: Point source emission limits to surface waters

Emission point reference	Parameter	Limit (including units)	Averaging period
S1000939 (PCT)	Total Nitrogen	3300 kg/d	Annual Period
	Total Phosphorus	1000 kg/d	

2.4 Point source emissions to groundwater

There are no specified conditions relating to point source emissions to groundwater in this section.

2.5 Emissions to land

2.5.1 The Licensee shall ensure that where waste is emitted to land from the emission points in Table 2.5.1 it is done so in accordance with the conditions of this Licence.

Table 2.5.1: Emissions to land

Emission point reference	Emission point reference	Description	Source including abatement
Effluent Discharge Pumping Station Sample point (Map of Infrastructure)	Irrigation areas within the Premises	Final plant outlet channel feeding irrigation areas	Treated wastewater

2.6 Fugitive emissions

There are no specified conditions relating to fugitive emissions in this section.

2.7 Odour

2.7.1 The Licensee shall ensure that odour emitted from the Premises does not unreasonably interfere with the health, welfare, convenience, comfort or amenity of any person beyond the odour boundary as depicted in the Map of Odour Boundary in Schedule 1.

2.8 Noise

There are no specified conditions relating to noise in this section.

3 Monitoring

3.1 General monitoring

3.1.1 The licensee shall ensure that:
(a) all water samples are collected and preserved in accordance with AS/NZS 5667.1;
(b) all wastewater samples are collected in accordance with AS/NZS 5667.10;
(c) all microbiological samples are collected in accordance with AS/NZS 2031;
(d) all laboratory samples are submitted to a laboratory with current NATA accreditation for the parameters to be measured unless indicated otherwise in relevant table.

3.1.2 The Licensee shall ensure that :
(a) monthly monitoring is undertaken at least 15 days apart;
(b) quarterly monitoring is undertaken at least 45 days apart; and
(c) six monthly monitoring is undertaken at least 5 months apart.

3.1.3 The Licensee shall record production or throughput data and any other process parameters relevant to any non-continuous or CEMS monitoring undertaken.

3.1.4 The Licensee shall ensure that all monitoring equipment used on the Premises to comply with the conditions of this Licence is calibrated in accordance with the manufacturer's specifications.

3.1.5 The Licensee shall, where the requirements for calibration cannot be practicably met, or a discrepancy exists in the interpretation of the requirements, bring these issues to the attention of the CEO accompanied with a report comprising details of any modifications to the methods.

3.2 Monitoring of point source emissions to air

3.2.1 The Licensee shall undertake the monitoring in Table 3.2.1 according to the specifications in that table.

Table 3.2.1: Monitoring of emissions to air

Emission point reference	Parameter	Units[1]	Frequency[2]	Method
S9 (Process control table)	Hydrogen sulphide	ppb	Continuous	CEMS
	Hydrogen sulphide	mg/m^3 g/s	Quarterly (March, June, September and December)	NATA accredited method for the measurement and analysis of hydrogen sulphide emissions from stationary sources
	Volumetric flow rate	m^3/s		Thermal mass flow meters calibrated against USEPA Method 2
	Stack exit temperature	degrees Celsius		None specified

Note 1: All units are referenced to STP dry
Note 2: Monitoring shall be undertaken to reflect normal operating conditions and any limits or conditions on inputs or production.

3.2.2 The Licensee shall ensure that sampling required under Condition 3.2.1 of the Licence is undertaken at sampling locations in compliance with the AS 4323.1 or relevant part of the CEMS Code.

3.2.3 The Licensee shall ensure that all non-continuous sampling and analysis undertaken pursuant to condition 3.2.1 for the parameters specified in Table 3.2.1 is undertaken by a holder of NATA accreditation for the relevant methods of sampling and analysis.

3.2.4 For any parameter in Table 3.2.1 requiring continuous monitoring, the Licensee shall ensure that the CEMS is regularly operated, maintained and calibrated in accordance with the CEMS Code.

3.3 Monitoring of point source emissions to surface water

3.3.1 The Licensee shall undertake the monitoring in Table 3.3.1 according to the specifications in that table.

Table 3.3.1: Monitoring of emissions to surface waters

Emission point	Monitoring point reference and location	Parameter	Units	Averaging period	Frequency
Swanbourne Ocean Outlet	Magflow to Ocean Outfall	Volumetric flow rate (cumulative)	L/s m^3/day	Monthly	Continuous
Perth Main Drain (via emergency overflow drain)	None specified				
Swanbourne Ocean Outlet and Perth Main Drain (via emergency overflow drain)	Effluent Discharge Pumping Station Sample point	pH[1]		Spot or composite sample	Monthly
		Total Nitrogen	mg/L		
		Total Phosphorus			
		Total Suspended Solids	mg/L		Six-monthly (October and April the following year)
		Total Dissolved Solids			
		Biochemical Oxygen Demand			
		Oil and Grease			
		Arsenic			
		Cadmium			
		Copper			
		Chromium			
		Lead			
		Mercury			
		Nickel			
		Zinc			

Note 1: In-field non-NATA accredited analysis permitted.

3.4 Monitoring of point source emissions to groundwater

There are no specified conditions relating to monitoring of point source emissions to groundwater in this section.

3.5 Monitoring of emissions to land

3.5.1 The Licensee shall undertake the monitoring in Table 3.5.1 according to the specifications in that table.

Table 3.5.1: Monitoring of emissions to land

Emission point	Monitoring point reference and location	Parameter	Units	Averaging period	Frequency
Effluent Discharge Pumping Station Sample point (Map of Infrastructure)	Magflow to on-site irrigation	Volumetric flow rate (cumulative)	L/s m^3/day	Monthly	When irrigating
	Magflow to reuse at McGillvray Oval				
	Effluent Discharge Pumping Station Sample point	pH[1]		Spot or composite sample	Monthly
		Total Nitrogen	mg/L		
		Total Phosphorus			
		Escherichia coli	Cfu/100ml		Quarterly
		Total Suspended Solids	mg/L		Six-monthly (October and April the following year)
		Total Dissolved Solids			
		Biochemical Oxygen Demand			

Note 1: In-field non-NATA accredited analysis permitted.

3.6 Monitoring of inputs and outputs

3.6.1 The Licensee shall undertake the monitoring specified in Table 3.6.1 according to the specifications in that table.

Table 3.6.1: Monitoring of inputs and outputs

Input/Output	Monitoring point reference	Parameter	Units	Averaging period	Frequency
Sewage - Inlet Flow	Inlet Channel Flow Meter (FT201)	Volumetric flow rate (cumulative)	L/s m^3/day	Monthly	Continuous
Septage wastes (Sewage) – domestic wastes from apparatus for the treatment of sewage	None specified	Volume (cumulative) of Controlled waste (by category) received at the WWTP	m^3/day tonnes	Monthly	Continuous
Treated wastewater discharged to on-site irrigation area	Outflow meter (M2)	Volumetric flow rate (cumulative)	m^3/day	Monthly	Continuous

Treated wastewater discharged to off-site irrigation area (McGillivray Oval)	Outflow meter (M2)	Volumetric flow rate (cumulative)	m^3/day	Monthly	Quarterly

3.7 Process monitoring

There are no specified conditions relating to process monitoring in this section.

3.8-3.9 Ambient environmental quality and meteorological monitoring

There are no specified conditions relating to ambient environmental quality or meteorological monitoring in this section.

4 Improvements

4.1 Improvement program

There are no specified improvement conditions in this section.

5 Information

5.1 Records

5.1.1 All information and records required by the Licence shall:
- (a) be legible;
- (b) if amended, be amended in such a way that the original and subsequent amendments remain legible or are capable of retrieval;
- (c) except for records listed in 5.1.1(d) be retained for at least 6 years from the date the records were made or until the expiry of the Licence or any subsequent licence; and
- (d) for those following records, be retained until the expiry of the Licence and any subsequent licence:
  - (i) off-site environmental effects; or
  - (ii) matters which affect the condition of the land or waters.

5.1.2 The Licensee shall ensure that:
- (a) any person left in charge of the Premises is aware of the conditions of the Licence and has access at all times to the Licence or copies thereof; and
- (b) any person who performs tasks on the Premises is informed of all of the conditions of the Licence that relate to the tasks which that person is performing.

5.1.3 The Licensee shall complete an Annual Audit Compliance Report indicating the extent to which the Licensee has complied with the conditions of the Licence, and any previous licence issued under Part V of the Act for the Premises for the previous annual period.

5.1.4 The Licensee shall:
- (a) implement a complaints management system that shall record the following information (if known or provided) about complaints received at the Premises concerning any environmental impact of the activities undertaken at the Premises:
  - (i) name and address of the complainants (if consented);
  - (ii) date and time of complaint;
  - (iii) date and time of alleged incident;
  - (iv) alleged source of the incident;
  - (v) general description of the alleged incident, including any environmental or health impacts reported by the complainant;

(vi) wind direction, wind speed and temperature at time of alleged incident;
(vii) likely source of the alleged incident; and
(viii) actions taken by licensee to address complaint, including the outcome of any investigation(s) and action(s) to verify any impacts.

(b) complete an annual analysis and review of complaints recorded under 5.1.4(a) to identify any common factors and root cause of complaints and proposals to address these.

5.2 Reporting

5.2.1 The Licensee shall submit to the CEO an Annual Environmental Report within 60 calendar days after the end of the annual period. The report shall contain the information listed in Table 5.2.1 in the format or form specified in that table.

Table 5.2.1: Annual Environmental Report

Condition or table (if relevant)	Parameter	Format or form[1]
-	Summary of any failure or malfunction of any pollution control equipment and any environmental incidents, that have occurred during the annual period and any action taken	None specified
Table 1.3.2	Summary of any treatment capacity target exceedances and any action taken.	None specified
3.2.1	Monitoring of emissions to air	None specified
3.3.1	Monitoring of emissions to surface waters	None specified
	Contaminant loading (kg/day – monthly average) to water (W1 and W2) of parameters monitored in Table 3.3.1 (except pH and Escherichia coli)	None specified
	Methodology and calculations used to estimate the daily volumetric flow rate of treated wastewater discharged to W2 and results of those calculations.	
3.5.1	Monitoring of emissions to land	None specified
	Contaminant loading (kg/day – monthly average) to land (for on-site irrigation areas – L1) of parameters monitored in Table 3.5.1 (except pH and Escherichia coli)	None specified
3.6.1	Monitoring of inputs and outputs	None specified
5.1.3	Compliance	AACR
5.1.4	Complaints summary	None specified
-	Summary of any changes to site boundaries, or sampling point location/name	None specified
-	The quantity of sewage sludge removed from the Premises	

Note 1: Forms are in Schedule 2

5.2.2 The Licensee shall ensure that the Annual Environmental Report also contains:
(a) any relevant process, production or operational data recorded under conditions of this licence; and
(b) an assessment of the information contained within the report against previous monitoring results and Licence limits and/or targets.

5.2.3 The Licensee shall submit the information in Table 5.2.2 to the CEO at the Contact Address according to the specifications in that table.

Table 5.2.2: Non-annual reporting requirements

Condition or table	Parameter	Reporting period	Reporting date (after end of the	Format or form

(if relevant)			reporting period)	
-	Copies of original monitoring reports submitted to the Licensee by third parties	Not Applicable	Within 14 days of the CEOs request	As received by the Licensee from third parties

5.3 Notification

5.3.1 The Licensee shall ensure that the parameters listed in Table 5.3.1 are notified to the CEO at the Contact Address and in accordance with the notification requirements of the table.

Table 5.3.1: Notification requirements

Condition or table (if relevant)	Parameter	Notification requirement[1]	Format or form[2]
-	Taking process equipment offline for maintenance works that may result in increase odour emissions.	No less than 72 hours in advance of works	None specified
2.1.1	Breach of any limit specified in the Licence	Part A: As soon as practicable but no later than 5pm of the next working day Part B: As soon as practicable	N1
-	Any failure or malfunction of any pollution control equipment or any incident which has caused, is causing or may cause pollution		
2.5.1	Discharges of treated wastewater into the Emergency overflow basin and then into Subiaco Main Drain.	Within 24 hours of becoming aware of such discharges.	None specified
3.1.5	Calibration report	as part of the AER	None specified

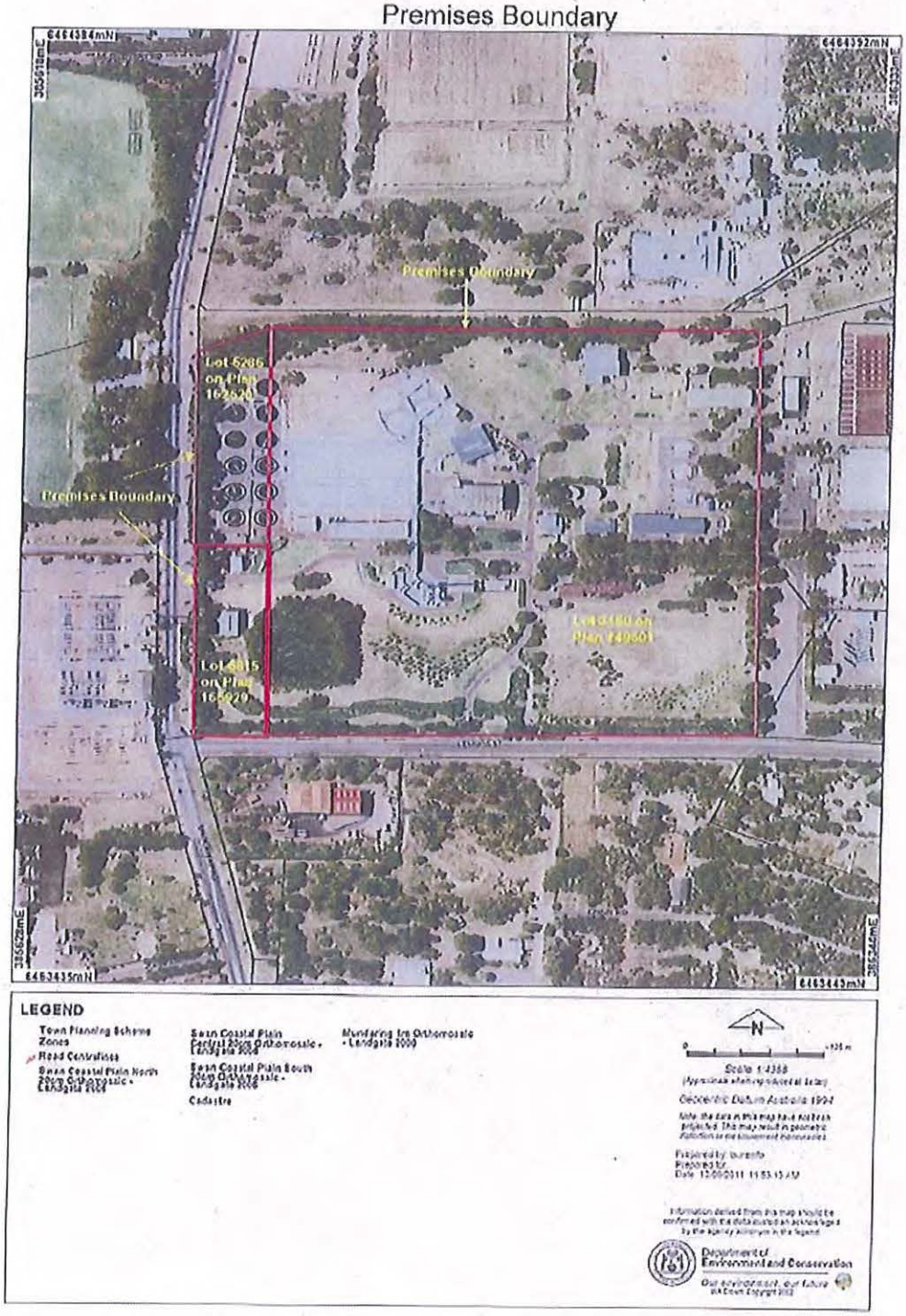
Note 1: No notification requirement in the Licence shall negate the requirement to comply with s72 of the Act.
Note 2: Forms are in Schedule 2

Schedule 1: Maps

Premises map

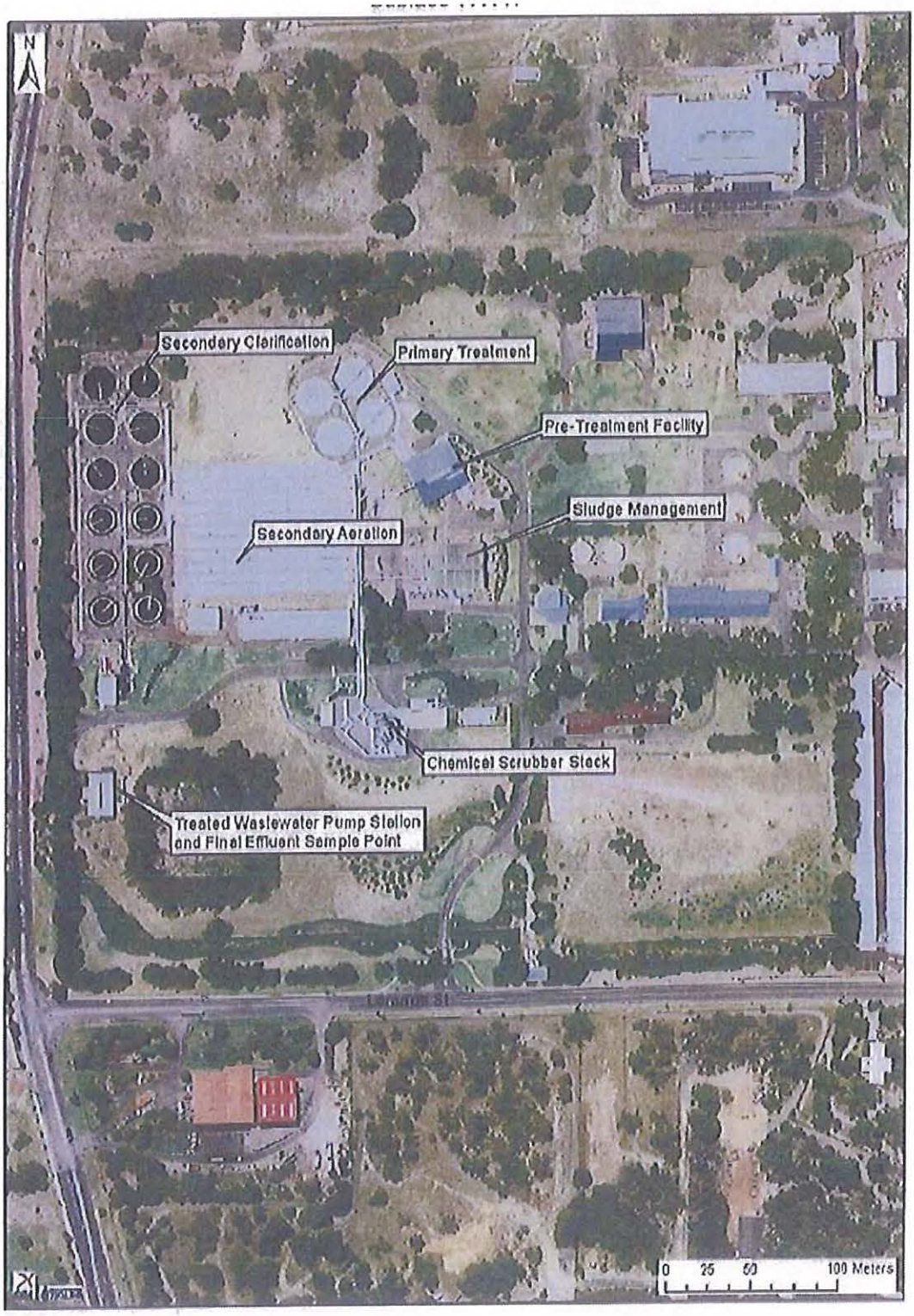
The Premises is shown in the map below. The pink line depicts the Premises boundary.

Premises Boundary



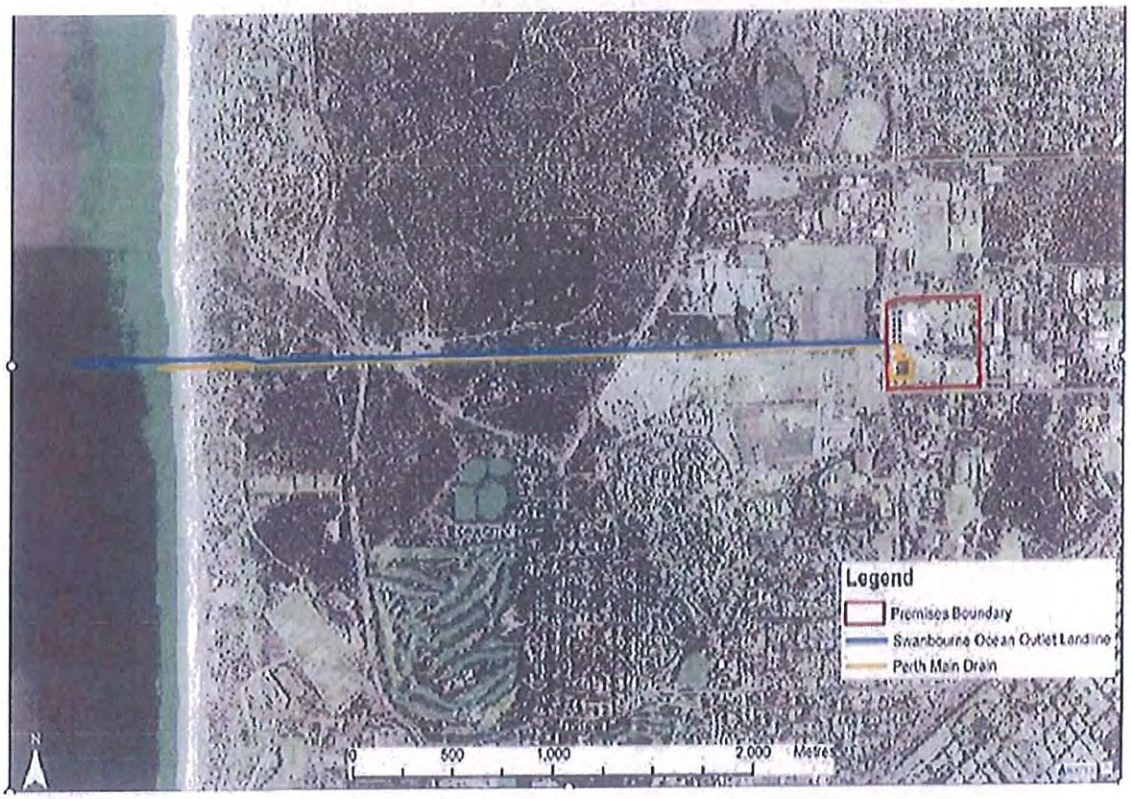
Map of plant infrastructure

The plant infrastructure is shown in the map below.



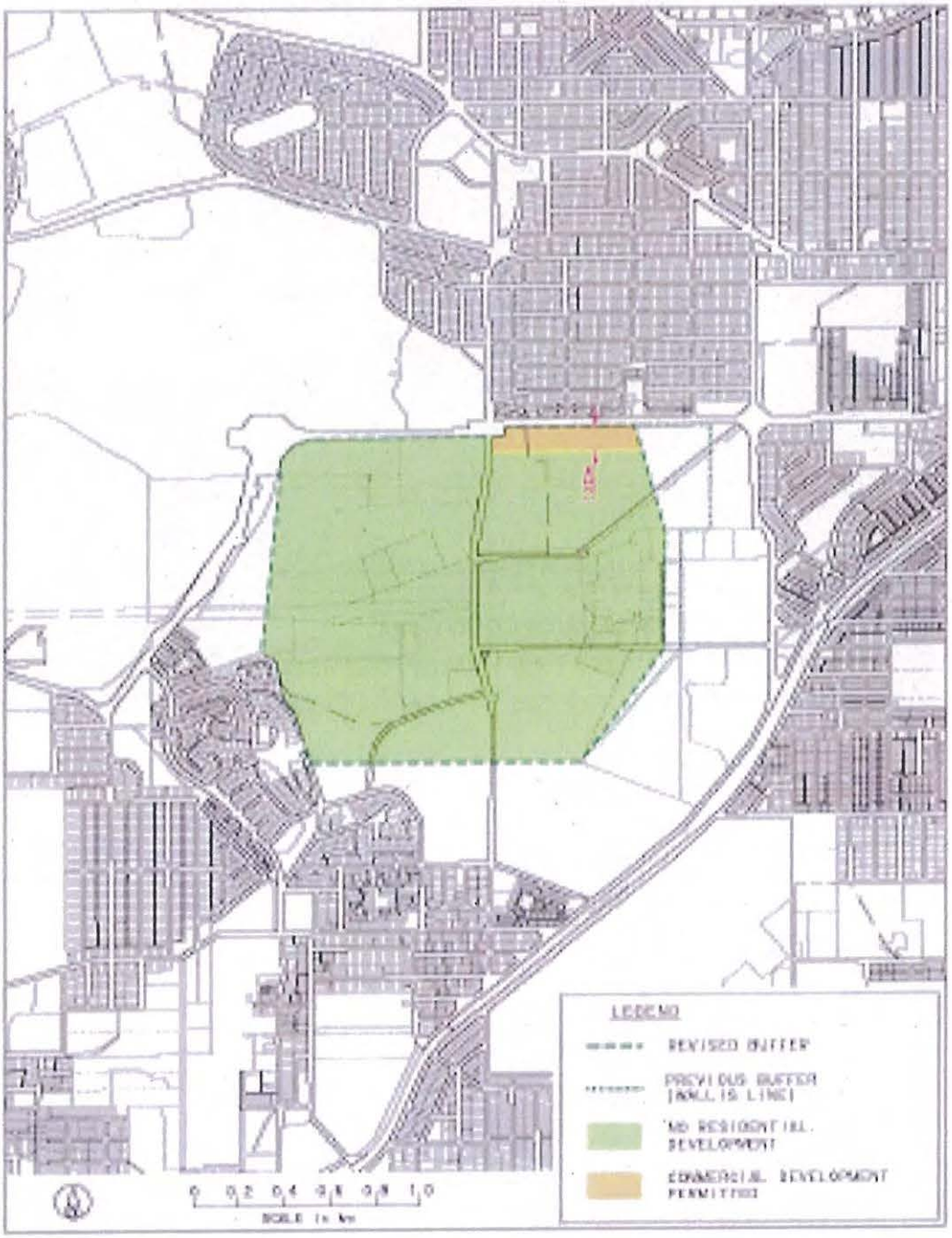
Map of Perth Main Drain and Swanbourne Ocean Outlet Landline

The Perth Main Drain and Swanbourne Ocean Outlet Landline are shown in the map below.



Map of Odour Boundary

REVISED BUFFER ZONE
FOR SUBIACO WASTEWATER TREATMENT PLANT



Schedule 2: Reporting & notification forms

These forms are provided for the proponent to report monitoring and other data required by the Licence. They can be requested in an electronic format.

ANNUAL AUDIT COMPLIANCE REPORT PROFORMA

SECTION A

LICENCE DETAILS

Licence Number:	Licence File Number:
Company Name: Trading as:	ABN:
Reporting period: _____ to _____	

STATEMENT OF COMPLIANCE WITH LICENCE CONDITIONS

1. Were all conditions of the Licence complied with within the reporting period? (please tick the appropriate box)

Yes ☐ Please proceed to Section C

No ☐ Please proceed to Section B

Each page must be initialled by the person(s) who signs Section C of this Annual Audit Compliance Report (AACR).

Initial:

SECTION B
DETAILS OF NON-COMPLIANCE WITH LICENCE CONDITION.

Please use a separate page for each licence condition that was not complied with.

a) Licence condition not complied with:	
b) Date(s) when the non compliance occurred, if applicable:	
c) Was this non compliance reported to DER?:	
☐ Yes ☐ Reported to DER verbally Date _____ ☐ Reported to DER in writing Date _____	☐ No
d) Has DER taken, or finalised any action in relation to the non compliance?:	
e) Summary of particulars of the non compliance, and what was the environmental impact:	
f) If relevant, the precise location where the non compliance occurred (attach map or diagram):	
g) Cause of non compliance:	
h) Action taken, or that will be taken to mitigate any adverse effects of the non compliance:	
i) Action taken or that will be taken to prevent recurrence of the non compliance:	

Each page must be initialled by the person(s) who signs Section C of this AACR

Initial:

SECTION C

SIGNATURE AND CERTIFICATION

This Annual Audit Compliance Report (AACR) may only be signed by a person(s) with legal authority to sign it. The ways in which the AACR must be signed and certified, and the people who may sign the statement, are set out below.

Please tick the box next to the category that describes how this AACR is being signed. If you are uncertain about who is entitled to sign or which category to tick, please contact the licensing officer for your premises.

If the licence holder is		The Annual Audit Compliance Report must be signed and certified:
An individual	□	by the individual licence holder, or
	□	by a person approved in writing by the Chief Executive Officer of the Department of Environment Regulation to sign on the licensee's behalf.
A firm or other unincorporated company	□	by the principal executive officer of the licensee; or
	□	by a person with authority to sign on the licensee's behalf who is approved in writing by the Chief Executive Officer of the Department of Environment Regulation.
A corporation	□	by affixing the common seal of the licensee in accordance with the *Corporations Act 2001*; or
	□	by two directors of the licensee; or
	□	by a director and a company secretary of the licensee, or
	□	if the licensee is a proprietary company that has a sole director who is also the sole company secretary – by that director, or
	□	by the principal executive officer of the licensee; or
	□	by a person with authority to sign on the licensee's behalf who is approved in writing by the Chief Executive Officer of the Department of Environment Regulation.
A public authority (other than a local government)	□	by the principal executive officer of the licensee; or
	□	by a person with authority to sign on the licensee's behalf who is approved in writing by the Chief Executive Officer of the Department of Environment Regulation.
a local government	□	by the chief executive officer of the licensee; or
	□	by affixing the seal of the local government.

It is an offence under section 112 of the *Environmental Protection Act 1986* for a person to give information on this form that to their knowledge is false or misleading in a material particular. There is a maximum penalty of $50,000 for an individual or body corporate.

I/We declare that the information in this annual audit compliance report is correct and not false or misleading in a material particular.

SIGNATURE: _____

NAME:
(printed) _____

POSITION: _____

DATE: _____/_____/_____

SIGNATURE: _____

NAME:
(printed) _____

POSITION: _____

DATE: _____/_____/_____

SEAL (if signing under seal)

Licence: L4726/1991/14 Licensee: Water Corporation
Form: N1 Date of breach:

Notification of detection of the breach of a limit or any failure or malfunction of any pollution control equipment or any incident which has caused, is causing or may cause pollution.

These pages outline the information that the operator must provide.
Units of measurement used in information supplied under Part A and B requirements shall be appropriate to the circumstances of the emission. Where appropriate, a comparison should be made of actual emissions and authorised emission limits.

Part A

Licence Number	
Name of operator	Water Corporation
Location of Premises	
Time and date of the detection	

Notification requirements for the breach of a limit	
Emission point reference/ source	
Parameter(s)	
Limit	
Measured value	
Date and time of monitoring	
Measures taken, or intended to be taken, to stop the emission	

Notification requirements for any failure or malfunction of any pollution control equipment or any incident which has caused, is causing or may cause pollution	
Date and time of event	
Reference or description of the location of the event	
Description of where any release into the environment took place	
Substances potentially released	
Best estimate of the quantity or rate of release of substances	
Measures taken , or intended to be taken, to stop any emission	
Description of the failure or accident	

Part B

Any more accurate information on the matters for notification under Part A.	
Measures taken, or intended to be taken, to prevent a recurrence of the incident.	
Measures taken, or intended to be taken, to rectify, limit or prevent any pollution of the environment which has been or may be caused by the emission.	
The dates of any previous N1 notifications for the Premises in the preceding 24 months.	

Name	
Post	
Signature on behalf of Water Corporation	
Date	

Government of Western Australia
Department of Environment Regulation

Decision Document

Environmental Protection Act 1986, Part V

Proponent: Water Corporation

Licence: L4726/1991/15

Registered office: 629 Newcastle Street
LEEDERVILLE WA 6007

Premises address: Subiaco Wastewater Treatment Plant
Lemnos Street
SHENTON PARK WA 6008
Being Lot 3150 on Plan 149501, Lot 5286 on Plan 162620 and Lot 6815 on Plan 166929 as depicted in Schedule 1.

Issue date: Thursday, 30 October 2014

Commencement date: Saturday, 1 November 2014

Expiry date: Tuesday, 31 November 2017

Decision

Based on the assessment detailed in this document the Department of Environment Regulation (DER), has decided to issue a licence. DER considers that in reaching this decision, it has taken into account all relevant considerations and legal requirements and that the Licence and its conditions will ensure that an appropriate level of environmental protection is provided.

Decision Document prepared by: Jane Dalin
Senior Licensing Officer

Decision Document authorised by: Rebecca Kelly
Manager Waste Sector, Licensing

Contents

1 Purpose of this Document

This decision document explains how DER has assessed and determined the application and provides a record of DER's decision-making process and how relevant factors have been taken into account. Stakeholders should note that this document is limited to DER's assessment and decision making under Part V of the *Environmental Protection Act 1986*. Other approvals may be required for the proposal, and it is the proponent's responsibility to ensure they have all relevant approvals for their Premises.

Works approval and licence conditions
DER has three types of conditions that may be imposed on works approvals and licences. They are as follows;

Standard conditions (SC)

DER has standard conditions that are imposed on all works approvals and licences regardless of the activities undertaken on the Premises and the information provided in the application. These are included as the following conditions on works approvals and licences:

Works approval conditions: 1.1.1-1.1.4, 1.2.1, 1.2.2, 5.1.1 and 5.1.2.

Licence conditions: 1.1.1-1.1.4, 1.2.1-1.2.4, 5.1.1-5.1.4 and 5.2.1.

For such conditions, justification within the Decision Document is not provided.

Optional standard conditions (OSC)

In the interests of regulatory consistency DER has a set of optional standard conditions that can be imposed on works approvals and licences. DER will include optional standard conditions as necessary, and are likely to constitute the majority of conditions in any licence. The inclusion of any optional standard conditions is justified in Section 4 of this document.

Non standard conditions (NSC)

Where the proposed activities require conditions outside the standard conditions suite DER will impose one or more non-standard conditions. These include both premises and sector specific conditions, and are likely to occur within few licences. Where used, justification for the application of these conditions will be included in Section 4.

2 Administrative summary

Administrative details		
Application type	Works Approval ☐ New Licence ☒ Licence amendment ☐ Works Approval amendment ☐	
Activities that cause the premises to become prescribed premises	**Category number(s)**	**Assessed design capacity**
	54	Not more than 61,400 m^3 per day
	61	Not more than 20,000 tonnes per annual period
Application verified Application fee paid	Date: 23/07/2014 Date:18/08/2014	
Works Approval has been complied with	Yes☐ No☐ N/A☒	
Compliance Certificate received	Yes☐ No☐ N/A☒	
Commercial-in-confidence claim	Yes☐ No☒	
Commercial-in-confidence claim outcome		
Is the proposal a Major Resource Project?	Yes☐ No☒	
Was the proposal referred to the Environmental Protection Authority (EPA) under Part IV of the *Environmental Protection Act 1986*?	Yes☐ No☒	Referral decision No: Managed under Part V ☒ Assessed under Part IV ☐
Is the proposal subject to Ministerial Conditions?	Yes☐ No☒	Ministerial statement No: EPA Report No:
Does the proposal involve a discharge of waste into a designated area (as defined in section 57 of the *Environmental Protection Act 1986*	Yes☐ No☒ Department of Water consulted Yes ☐ No ☒	
Is the Premises within an Environmental Protection Policy (EPP) Area Yes☐ No☒ If Yes include details of which EPP(s) here.		
Is the Premises subject to any EPP requirements? Yes☐ No☒ If Yes, include details here, eg Site is subject to SO_2 requirements of Kwinana EPP.		

3 Executive summary of proposal and assessment

Water Corporation has operated the Subiaco Wastewater Treatment Plant (WWTP) under the *Environmental Protection Act 1986* Licence L4726/1991/14.

The operations at Water Corporation's Subiaco Wastewater Treatment Plant include:

- the treatment of domestic and commercial sewage via an activated sludge treatment plant which treats the wastewater to a secondary standard;
- reuse of treated wastewater as process water and for landscape irrigation;
- reuse of treated wastewater at McGillivray Oval for landscape irrigation;
- discharge of surplus treated wastewater to the ocean via an ocean outlet located off Swanbourne Beach; and
- treatment and storage of sewage sludge on-site within sludge treatment and storage tanks.

The main potential emissions from the site are discharges of treated wastewater to water and fugitive emissions in the form of odour.

Discharges of treated wastewater to water are managed by treating wastewater to a defined water quality level and undertaking compliance monitoring prior to discharge.

Odour is managed on-site through scrubbing combined odours from the influent channel, pre-treatment building, primary treatment and sludge treatment in the primary odour scrubbers at the odour control facility. Gas extracted from the secondary aeration tanks is combined with the air discharged from the primary scrubbers and scrubbed in the two odour-guard scrubbers. The odour control system is currently monitored by an external service provider. Tests for temperature, air flow rates and H2S concentrations are conducted on a monthly basis.

The licence is due to expire on 31 October 2014. This document has been prepared for the reissue of the licence. DER has now converted the licence into the new standardised REFIRE (Re-Engineering for Industry Regulation and the Environment) format. During the conversion process, DER has not reassessed the acceptability or impacts of emissions and discharges from the premises or re-visited any existing emission control levels.

4 Decision table

All applications are assessed in line with the *Environmental Protection Act 1986*, the *Environmental Protection Regulations 1987*, DEC's Policy Statement - Limits and targets for prescribed premises (2006), and DER's Operational Procedure on Assessing Emissions and Discharges from Prescribed Premises. Where other references have been used in making the decision they are detailed in the decision document.

DECISION TABLE				
Works Approval / Licence section	**Condition number W = Works Approval L= Licence**	**OSC or NSC**	**Justification (including risk description & decision methodology where relevant)**	**Reference documents**
General conditions	L1.3.2 L1.3.3 L1.3.4 L1.3.5 L1.3.6	OSC	**Operation** Waste acceptance. Existing licence (X5) only stipulates tankered waste for acceptance onto the premises. Sewage waste has also been included on the new condition. Stipulates permitted processes for waste. Stipulates containment infrastructure requirements for waste materials, including cover requirements for pre-treatment and secondary aeration areas. This replaces existing X2. This condition has been added to maintain sufficient freeboard on all treatment and storage tanks to prevent overflows during extreme weather conditions. This condition has been added to maintain the irrigation area on site.	
Emissions general	L2.1.1	OSC	There will be discharge of treated wastewater to the Swanbourne ocean outlet (surface water) and a discharge to air. Therefore, OSC regarding recording and investigation of exceedances of any descriptive limits or targets have been included.	Application supporting documentation

DECISION TABLE				
Works Approval / Licence section	**Condition number W = Works Approval L= Licence**	**OSC or NSC**	**Justification (including risk description & decision methodology where relevant)**	**Reference documents**
				General provisions of the *Environmental Protection Act 1986*
Point source emissions to air including monitoring	L2.2.1 - L2.2.3	OSC	Authorisation to emit waste through chemical scrubber stack. A limit of hydrogen sulphide has been set in the licence. This replaces condition A1, M1 (a – c) and M2.	Application supporting documentation General provisions of the *Environmental Protection Act 1986*
Point source emissions to surface water including monitoring	L2.3.1 - L2.3.3	OSC	Authorisation to emit waste through Swanbourne ocean outlet and to the Subiaco Main Drain. There will be discharge of treated wastewater to the Swanbourne ocean outlet (surface water). Limits are included in the licence. This replaces conditions X4(a) and M3 (a - e). Limits for TN and TP at the Swanbourne ocean outlet replaces condition W2 (a & b)	Application supporting documentation General provisions of the *Environmental Protection Act 1986*
Point source emissions to groundwater including monitoring	N/A	N/A	There are no point source emissions to groundwater from the premises that require regulation	N/A

DECISION TABLE				
Works Approval / Licence section	**Condition number W = Works Approval L= Licence**	**OSC or NSC**	**Justification (including risk description & decision methodology where relevant)**	**Reference documents**
Emissions to land including monitoring	L3.5.1	OSC	Requires monitoring of effluent prior to its discharge to irrigation as detailed in Table 3.5.1. This condition replaces conditions M3 (a) of the previous Licence.	Application supporting documentation General provisions of the *Environmental Protection Act 1986*
Fugitive emissions	N/A	N/A	Fugitive emissions have not been reassessed as part of this reissue	N/A
Odour	L 2.7.1	OSC	L2.7.1 is a standard REFIRE OSC. Odour has been managed through point source emissions to air section.	General provisions of the *Environmental Protection Act 1986*
Noise	N/A	N/A	Noise has not been reassessed as part of this reissue. No specific conditions have been included in this section. The *Environmental Protection (Noise) Regulations 1997* and SC1.2.1 apply	*Environmental Protection (Noise) Regulations 1997*
Monitoring general	L3.1.1 L3.1.2 L3.1.3 L3.1.4 L3.1.5 L3.2.2 L3.2.3 L3.2.4	OSC	Replaces M1(c), M3(c) and M3(e) Monitoring frequency Record production or throughput data and any other process parameters. Monitoring equipment calibration replaces M1(b). Calibration notification. NATA accreditation for the relevant methods of sampling and analysis – point source air emissions. Replaces M1(b). CEMS maintained and calibrated in accordance with CEMS Code and operational requirements.	General provisions of the *Environmental Protection Act 1986*

DECISION TABLE				
Works Approval / Licence section	**Condition number W = Works Approval L= Licence**	**OSC or NSC**	**Justification (including risk description & decision methodology where relevant)**	**Reference documents**
Monitoring of inputs and outputs	L3.6.1	OSC	This condition has been added to the Licence for monitoring of inputs and outputs and it replaces condition M3(a) & X5 of the previous licence.	General provisions of the *Environmental Protection Act 1986*
Process monitoring	N/A	N/A	It is covered under emission to land, air and surface water. Water quality is to be monitored prior to its discharge to land and surface water.	General provisions of the *Environmental Protection Act 1986*
Ambient quality monitoring	N/A	N/A	Ambient quality monitoring has not been reassessed as part of this reissue. There are no specified conditions in this section.	General provisions of the *Environmental Protection Act 1986*
Meteorological monitoring	N/A	N/A	Meteorological monitoring has not been reassessed as part of this reissue. There are no specified conditions in this section.	N/A
Improvements	N/A	N/A	No improvement conditions have been added in the Licence	
Information	L5.1.1 – L5.1.4 and L5.2.1 L5.2.2 L5.3.1	SC OSC	These are standard REFIRE conditions AER requirements (replaces R2) Notification requirements (replaces X4(b)	
Licence Duration	N/A	N/A	Due to the location to sensitive receptors and a large ocean outfall it is a medium risk category premises. The licence can be issued for a period of three years.	

5 Advertisement and consultation table

Date	Event	Comments received/Notes	How comments were taken into consideration
27/10/14	Email from Rod Brooks – Water Corporation	Comments on the draft licence	All comments were taken in to consideration and changed accordingly. All comments were accepted and changed. All comments from Water Corporation were either related to the wrong process or technical wording.

6 Risk Assessment

Note: This matrix is taken from the DER Corporate Policy Statement No. 07 - Operational Risk Management

Table 1: Emissions Risk Matrix

Likelihood	Consequence				
	Insignificant	Minor	Moderate	Major	Severe
Almost Certain	Moderate	High	High	Extreme	Extreme
Likely	Moderate	Moderate	High	High	Extreme
Possible	Low	Moderate	Moderate	High	Extreme
Unlikely	Low	Moderate	Moderate	Moderate	High
Rare	Low	Low	Moderate	Moderate	High

Government of **Western Australia**
Department of **Environment Regulation**

FILE NOTE

FROM:	**Dr Bhabesh Das**
DATE:	**31 October 2014**
SUBJECT:-	**Water Corporation Licence Reissue** **Licence No. L4726/1991/15**
PREMISES:	**Subiaco Wastewater Treatment Plant** **Lot 3150 on Plan 149501, Lot 5286 on Plan 162620 and Lot 6815 on Plan 166929, lemnos street, SHENTON PARK WA 6008**
FILE NO:	**DEC 794-02**

Water Corporation has applied for reissue of the licence for Subiaco WWTP. The licence is due to expire on **31 October 2014**. The licence conditions have been transferred to REFIRE format and a Decision Document has been prepared. Due to time constraint DER will liaise with the Water Corporation to amend the licence in next 3-6 months to incorporate to groundwater monitoring conditions.

Appendix B – Analytical laboratories and methods

Analytical Laboratories

Analytes determined and analytical laboratories used for treated wastewater characterisation

Analytes	Analytical Laboratory	Analytical Method	Reporting Limit	Unit
Microbiological				
E.coli	PathWest Laboratory Medicine WA	Membrane filtration	Dilution dependent(1)	CFU 100 mL^{-1}
Enterococci	PathWest Laboratory Medicine WA	Membrane filtration	Dilution dependent(1)	MPN 100 mL^{-1}
Nutrients				
Ortho-phosphate	Murdoch University Marine and Freshwater Research Laboratory (MAFRL) and/or National Measurement Institute (NMI)	Lachat-Automated Flow Injection Analyser (4100)	2(2)	µg P L^{-1}
Ammonia		Lachat-Automated Flow Injection Analyser (2000)	3(2)	µg N L^{-1}
Nitrate + Nitrite		Lachat-Automated Flow Injection Analyser (2100)	2(2)	µg N L^{-1}
Total Nitrogen		Lachat-Automated Flow Injection Analyser (2700)	50(2)	µg N L^{-1}
Total Phosphorus		Lachat-Automated Flow Injection Analyser (4700)	5(2)	µg P L^{-1}
Metals and Metalloids				
Arsenic filtered	National Measurement Institute (NMI)	Inductively coupled plasma mass spectrometry and inductively coupled plasma atomic emission spectrometry (NT2.47.251)	1	µg L^{-1}
Arsenic total		NT2.47.251	1	µg L^{-1}
Cadmium filtered		Inductively coupled plasma mass spectrometry and inductively coupled plasma atomic emission spectrometry (NT2.47)	0.1	µg L^{-1}
Cadmium total		NT2.47	0.1	µg L^{-1}
Chromium filtered		NT2.47	2	µg L^{-1}
Chromium total		NT2.47	2	µg L^{-1}
Copper filtered		NT2.47	1	µg L^{-1}
Copper total		NT2.47	1	µg L^{-1}
Lead filtered		NT2.47	1	µg L^{-1}
Lead total		NT2.47	1	µg L^{-1}
Mercury filtered		Inductively coupled plasma mass spectrometry and inductively coupled plasma atomic emission spectrometry (NT2.47.244)	0.1	µg L^{-1}
Mercury total		NT2.47.244	0.1	µg L^{-1}
Nickel filtered		NT2.47	2	µg L^{-1}
Nickel total		NT2.47	2	µg L^{-1}
Selenium filtered		NT2.47.251	1	µg L^{-1}
Selenium total		NT2.47	1	µg L^{-1}
Silver filtered		NT2.47	0.8	µg L^{-1}
Silver total		NT2.47	0.8	µg L^{-1}
Zinc filtered		NT2.47	2	µg L^{-1}
Zinc total		NT2.47	2	µg L^{-1}

Analytes	Analytical Laboratory	Analytical Method	Reporting Limit	Unit
Phenoxy Acid Herbicides				
Dicamba	National Measurement Institute (NMI)	Electron Impact Full Scan or Selected Ion Monitoring (NGCMS_1117)	1	$\mu g\ L^{-1}$
MCPA		NGCMS_1117	1	$\mu g\ L^{-1}$
Dichlorprop		NGCMS_1117	1	$\mu g\ L^{-1}$
2,4-D		NGCMS_1117	1	$\mu g\ L^{-1}$
2, 4, 5-T		NGCMS_1117	1	$\mu g\ L^{-1}$
2 4, 5 –TP		NGCMS_1117	1	$\mu g\ L^{-1}$
2, 4-DB		NGCMS_1117	1	$\mu g\ L^{-1}$
MCPP		NGCMS_1117	1	$\mu g\ L^{-1}$
Trichlopyr		NGCMS_1117	1	$\mu g\ L^{-1}$
Triazine Herbicides				
Atrazine	National Measurement Institute (NMI)	Extraction, Cleanup and Analysis (NR_19)	0.1	$\mu g\ L^{-1}$
Hexazinone		NR_19	0.1	$\mu g\ L^{-1}$
Metribuzine		NR_19	0.1	$\mu g\ L^{-1}$
Prometryne		NR_19	0.1	$\mu g\ L^{-1}$
Simazine		NR_19	0.1	$\mu g\ L^{-1}$
Organophosphate Pesticides				
Azinphos-Methyl	National Measurement Institute (NMI)	NR_19	0.1	$\mu g\ L^{-1}$
Azinphos-Ethyl		NR_19	0.1	$\mu g\ L^{-1}$
Chlorpyrifos		NR_19	0.1	$\mu g\ L^{-1}$
Chlorpyrifos Methyl		NR_19	0.1	$\mu g\ L^{-1}$
Chlorfenvinophos (E)		NR_19	0.1	$\mu g\ L^{-1}$
Chlorfenvinphos (Z)		NR_19	0.1	$\mu g\ L^{-1}$
Demeton-S-Methyl		NR_19	0.1	$\mu g\ L^{-1}$
Dichlorvos		NR_19	0.1	$\mu g\ L^{-1}$
Diazinon		NR_19	0.1	$\mu g\ L^{-1}$
Dimethoate		NR_19	0.1	$\mu g\ L^{-1}$
Ethion		NR_19	0.1	$\mu g\ L^{-1}$
Fenthion		NR_19	0.1	$\mu g\ L^{-1}$
Fenitrothion		NR_19	0.1	$\mu g\ L^{-1}$
Malathion		NR_19	0.1	$\mu g\ L^{-1}$
Parathion (Ethyl)		NR_19	0.1	$\mu g\ L^{-1}$
Parathion Methyl		NR_19	0.1	$\mu g\ L^{-1}$
Pirimiphos-Ethyl		NR_19	0.1	$\mu g\ L^{-1}$
Pirimiphos-Methyl		NR_19	0.1	$\mu g\ L^{-1}$
Organochlorine Pesticides				
Aldrin	National Measurement Institute (NMI)	NR_19	0.01	$\mu g\ L^{-1}$
trans-Chlordane		NR_19	0.01	$\mu g\ L^{-1}$
cis-Chlordane		NR_19	0.01	$\mu g\ L^{-1}$
Oxychlordane		NR_19	0.01	$\mu g\ L^{-1}$
BHC (other than lindane)		NR_19	0.01	$\mu g\ L^{-1}$
DDD		NR_19	0.01	$\mu g\ L^{-1}$
DDE		NR_19	0.01	$\mu g\ L^{-1}$
DDT		NR_19	0.01	$\mu g\ L^{-1}$
Dieldrin		NR_19	0.01	$\mu g\ L^{-1}$
Endrin		NR_19	0.01	$\mu g\ L^{-1}$
Endrin Aldehyde		NR_19	0.01	$\mu g\ L^{-1}$
Endrin Ketone		NR_19	0.01	$\mu g\ L^{-1}$
alpha-Endosulfan		NR_19	0.01	$\mu g\ L^{-1}$
beta-Endosulfan		NR_19	0.01	$\mu g\ L^{-1}$
Endosulfan Sulfate		NR_19	0.01	$\mu g\ L^{-1}$
HCB		NR_19	0.01	$\mu g\ L^{-1}$

Analytes	Analytical Laboratory	Analytical Method	Reporting Limit	Unit
Heptachlor		NR_19	0.01	µg L^{-1}
Heptachlor epoxide		NR_19	0.01	µg L^{-1}
Lindane		NR_19	0.01	µg L^{-1}
Methoxychlor		NR_19	0.01	µg L^{-1}
Phthalates				
Dimethyl phthalate	National Measurement Institute (NMI)	Electron Impact or Selected Ion Monitoring (NGCMS_1111)	10	µg L^{-1}
Diethyl phthalate		NGCMS_1111	10	µg L^{-1}
Di-n-butyl phthalate		NGCMS_1111	10	µg L^{-1}
Benzyl butyl phthalate		NGCMS_1111	10	µg L^{-1}
Bis(2-ethylhexyl)phthalate		NGCMS_1111	20	µg L^{-1}
Di-n-octyl phthalate		NGCMS_1111	10	µg L^{-1}
PCB Aroclors				
Aroclor 1016	National Measurement Institute (NMI)	NR_19	0.1	µg L^{-1}
Aroclor 1221		NR_19	0.1	µg L^{-1}
Aroclor 1232		NR_19	0.1	µg L^{-1}
Aroclor 1242		NR_19	0.1	µg L^{-1}
Aroclor 1248		NR_19	0.1	µg L^{-1}
Aroclor 1254		NR_19	0.1	µg L^{-1}
Aroclor 1260		NR_19	0.1	µg L^{-1}
Total PCBs (as above)		NR_19	0.1	µg L^{-1}
Chlorinated Hydrocarbons				
2-Chloronaphthalene	National Measurement Institute (NMI)	Extraction, Filtration and Analysis using a modified USEPA 8270 method (NGCMS_1122)	20	µg L^{-1}
1,4-Dichlorobenzene		NGCMS_1122	20	µg L^{-1}
1,2-Dichlorobenzene		NGCMS_1122	20	µg L^{-1}
1,3-Dichlorobenzene		NGCMS_1122	20	µg L^{-1}
Hexachlorobenzene		NGCMS_1122	20	µg L^{-1}
1,2,4-Trichlorobenzene		NGCMS_1122	20	µg L^{-1}
Hexachloroethane		NGCMS_1122	20	µg L^{-1}
Hexachlorocyclopentadiene		NGCMS_1122	20	µg L^{-1}
Hexachloro-1,3-butadiene		NGCMS_1122	20	µg L^{-1}
Ethers				
4-Bromophenyl phenyl ether	National Measurement Institute (NMI)	NGCMS_1122	20	µg L^{-1}
4-Chlorophenyl phenyl ether		NGCMS_1122	20	µg L^{-1}
Bis(2-chloroethyl)ether		NGCMS_1122	20	µg L^{-1}
Bis(2-chloroethoxy)methane		NGCMS_1122	20	µg L^{-1}
Bis(2-chloroisopropyl)ether		NGCMS_1122	20	µg L^{-1}
Amines, Nitroaromatics & Nitrosamines				
Azobenzene	National Measurement Institute (NMI)	NGCMS_1122	20	µg L^{-1}
2,4-Dinitrotoluene		NGCMS_1122	20	µg L^{-1}
2,6-Dinitrotoluene		NGCMS_1122	20	µg L^{-1}
Nitrobenzene		NGCMS_1122	20	µg L^{-1}
NNitrosodimethylamine		NGCMS_1122	20	µg L^{-1}
N-Nitrosodiphenylamine		NGCMS_1122	20	µg L^{-1}
N-Nitrosodi-n-		NGCMS_1122	20	µg L^{-1}

Analytes	Analytical Laboratory	Analytical Method	Reporting Limit	Unit
propylamine				
Aniline		NGCMS_1122	20	µg L^{-1}
4-Chloroaniline		NGCMS_1122	20	µg L^{-1}
2-Nitroaniline		NGCMS_1122	20	µg L^{-1}
3-Nitroaniline		NGCMS_1122	20	µg L^{-1}
4-Nitroaniline		NGCMS_1122	20	µg L^{-1}
Other Organics				
Dichlorobenzidine	National Measurement Institute (NMI)	NGCMS_1122	20	µg L^{-1}
2-Methylnaphthalene		NGCMS_1122	10	µg L^{-1}
Isophorone		NGCMS_1122	20	µg L^{-1}
Benzyl alcohol		NGCMS_1122	20	µg L^{-1}
Carbazole		NGCMS_1122	20	µg L^{-1}
Dibenzofuran		NGCMS_1122	20	µg L^{-1}
BTEX				
Benzene	National Measurement Institute (NMI)	Purge and trap technique with GC/FID (WL244)	1	µg L^{-1}
Toluene		WL244	1	µg L^{-1}
Ethylbenzene		WL244	1	µg L^{-1}
Xylene		WL244	2	µg L^{-1}
Total BTEX		WL244	5	µg L^{-1}
TPH				
TPH C6-C9	National Measurement Institute (NMI)	WL244	25	µg L^{-1}
TPH C10-C14		Gas chromatography with flame ionisation detection (WL203)	25	µg L^{-1}
TPH C15-C28		WL203	100	µg L^{-1}
TPH C29-C36		WL203	100	µg L^{-1}
Total Petroleum Hydrocarbons (TPH)		WL203	250	µg L^{-1}
PAHs				
Naphthalene	National Measurement Institute (NMI)	NGCMS_1111	0.1	µg L^{-1}
Acenaphthylene		NGCMS_1111	0.1	µg L^{-1}
Acenaphthene		NGCMS_1111	0.1	µg L^{-1}
Fluorene		NGCMS_1111	0.1	µg L^{-1}
Phenanthrene		NGCMS_1111	0.1	µg L^{-1}
Anthracene		NGCMS_1111	0.1	µg L^{-1}
Fluoranthene		NGCMS_1111	0.1	µg L^{-1}
Pyrene		NGCMS_1111	0.1	µg L^{-1}
Benzo(a)anthracene		NGCMS_1111	0.1	µg L^{-1}
Chrysene		NGCMS_1111	0.1	µg L^{-1}
Benzo(b)&(k)fluoranthene		NGCMS_1111	0.1	µg L^{-1}
Benzo(a)pyrene		NGCMS_1111	0.1	µg L^{-1}
Indeno(1,2,3-cd)pyrene		NGCMS_1111	0.1	µg L^{-1}
Dibenz(ah)anthracene		NGCMS_1111	0.1	µg L^{-1}
Benzon(ghi)perylene		NGCMS_1111	0.1	µg L^{-1}
Surfactants				
methylene blue active substances (MBAS) *	SGS Australia	Methylene dye added, extraction and colorimetrically measured based on test APHA 5540C	n/a	n/a
Miscellaneous Other				
Chlorine-Free	National Measurement Institute (NMI)	Colour test by comparision with coloured disc (WL146)	0.02	mg/L
Chlorine-Total		WL146	0.02	mg/L
Dissolved Organic		Split Sample and Compare	n/a	mg/L

Analytes	Analytical Laboratory	Analytical Method	Reporting Limit	Unit
Carbon (after filtering)		Total Carbon and Inorganic Carbon measured with Infrared Detector – Based on Method APHA 5310B (WL240)		
Total Organic Carbon		WL240	n/a	mg/L
Total Suspended Solids		Gravimetric Procedure – Based on APHA Methods 2540D and E (WL126)	5	mg/L
5-day Biological Oxygen Demand		5 Day Incubation of Neutralised, Chlorine Free Sample – Based on APHA Method 5210B (WL189)	5	mg/L
pH		Measured Potentiometrically Using a Combination Electrode (WL120)	0.1	pH unit

Notes:

1. The upper and lower detection limits for microbiological indicators are dependent on the dilution of the original sample.
2. Method detection limit determined from 3.2 x standard deviation of 10 standard samples.
   n/a = information not available

Analytical methods and reporting limits for water quality parameters

Parameter	Analytical Method(1)	Reporting Limit	Unit
Nutrients			
Ortho-phosphate	Lachat-Automated Flow Injection Analyser (4100)	2(2)	µg P L^{-1}
Ammonia	Lachat-Automated Flow Injection Analyser (4100)	3(2)	µg P L^{-1}
Nitrate + Nitrite	Lachat-Automated Flow Injection Analyser (4100)	2(2)	µg P L^{-1}
Primary Production			
Chlorophyll-a	Acetone extraction (3000)	0.1(2)	µg P L^{-1}
Phaeophytin	Acetone extraction (3000)	0.1(2)	µg P L^{-1}
Microbiological Indicators			
E.coli	Membrane filtration	Dilution dependent(3)	CFU 100 ml^{-1}
Enterococci	Membrane filtration	Dilution dependent(3)	CFU 100 ml^{-1}

Notes:

1. Numbers in brackets refer to the MAFRL analysis method number.
2. Method detection limit determined from 3.2 x standard deviation of 10 standard samples.
3. The upper and lower detection limits for microbiological indicators are dependent on the dilution of the original sample.

Appendix C – Comprehensive treated wastewater characterisation results

Parameter	Swanbourne	ANZECC/ARMCANZ (2000a) guidelines (µg/L)[1]				
	TWW	Level of protection				Low reliability value (LRV)
	16 Feb 2016	99%	95%	90%	80%	
Microbiological						
Confirmed *Enterococci* (MPN/100 mL)[2]	>24 000	n/a[3]	n/a	n/a	n/a	n/a
Presumptive thermotolerant coliforms (TTC; CFU/100 mL)[4]	640 000	n/a	n/a	n/a	n/a	n/a
Confirmed TTC (CFU/100 mL)[4]	640 000	n/a	n/a	n/a	n/a	n/a
Escherichia coli (CFU/100 mL)	640 000	n/a	n/a	n/a	n/a	n/a
Nutrients (µg/L)						
Ammonia-N	**610**	**500**	910	1200	1700	-
Nitrate-N+Nitrite-N	8000	ID[5]	ID	ID	ID	13,000
Nitrogen-Total N	13 000	n/a	n/a	n/a	n/a	n/a
Phosphate-Ortho as P	4400	n/a	n/a	n/a	n/a	n/a
Phosphorous-Total P	6100	n/a	n/a	n/a	n/a	n/a
'Dissolved' (0.45 µm filtered) (µg/L)						
Arsenic (As)	<1.0	ID	ID	ID	ID	2.3 (As III) 4.5 (As V)
Cadmium (Cd)	<0.1	0.7	5.5	14	36	-
Chromium (Cr)	<1.0	7.7 (Cr III) 0.14 (Cr VI)	27.4 (Cr III) 4.4 (Cr VI)	48.6 (Cr III) 20 (Cr VI)	90.6 (Cr III) 85 (Cr VI)	-
Copper (Cu)	**7**	**0.3**	1.3	3	8	-
Lead (Pb)	<1.0	2.2	4.4	6.6	12	-
Mercury (Hg)	<0.1	0.1	0.4	0.7	1.4	-
Nickel (Ni)	2	7	70	200	560	-
Selenium (Se)	<1.0	ID	ID	ID	ID	3
Silver (Ag)	<0.8	0.8	1.4	1.8	2.6	-
Zinc (Zn)	**39**	**7**	15	23	43	-
Total metals (acid extractable; unfiltered) (µg/L)						
Arsenic (As)	1	ID	ID	ID	ID	2.3 (As III) 4.5 (AsV)
Cadmium (Cd)	<0.1	0.7	5.5	14	36	-
Chromium (Cr)	<1.0	7.7 (Cr III) 0.14 (Cr VI)	27.4 (Cr III) 4.4 (Cr VI)	48.6 (Cr III) 20 (Cr VI)	90.6 (Cr III) 85 (Cr VI)	-
Copper (Cu)	**16**	**0.3**	1.3	3	8	-
Lead (Pb)	<1.0	2.2	4.4	6.6	12	-
Mercury (Hg)	<0.1	0.1	0.4	0.7	1.4	-
Nickel (Ni)	2	7	70	200	560	-
Selenium (Se)	<1.0	ID	ID	ID	ID	3
Silver (Ag)	<0.8	0.8	1.4	1.8	2.6	-
Zinc (Zn)	**47**	**7**	15	23	43	-
Triazine herbicides (µg/L)						
Atrazine	<0.1	ID	ID	ID	ID	13
Hexazinone	<0.1	ID	ID	ID	ID	75
Metribuzine	–	n/a	n/a	n/a	n/a	n/a
Prometryne	<0.1	n/a	n/a	n/a	n/a	n/a

Parameter	Swanbourne	ANZECC/ARMCANZ (2000a) guidelines (µg/L)[1]				
	TWW	Level of protection				Low reliability value (LRV)
	16 Feb 2016	99%	95%	90%	80%	
Simazine	<0.1	ID	ID	ID	ID	3.2
Phenoxy acid herbicides (µg/L)						
Dicamba[6]	<1	n/a	n/a	n/a	n/a	n/a
MCPA	<1	ID	ID	ID	ID	1.4
Dichlorprop	<1	n/a	n/a	n/a	n/a	n/a
2,4-D	<1	ID	ID	ID	ID	280
2,4,5-T	<1	n/a	n/a	n/a	n/a	n/a
2,4,5-TP	<1	n/a	n/a	n/a	n/a	n/a
2,4-DB	<1	n/a	n/a	n/a	n/a	n/a
MCPP	<1	n/a	n/a	n/a	n/a	n/a
Triclopyr[7]	<1	n/a	n/a	n/a	n/a	n/a
Organophosphate pesticides (µg/L)						
Azinphos-Methyl	<0.1	ID	ID	ID	ID	0.01
Azinphos-Ethyl	<0.1	n/a	n/a	n/a	n/a	n/a
Chlorpyrifos	<0.1	0.0005	0.009	0.04	0.3	-
Chlorfenvinphos (E)	<0.1	n/a	n/a	n/a	n/a	n/a
Chlorfenvinphos (Z)	<0.1	n/a	n/a	n/a	n/a	n/a
Demeton-S-Methyl	<0.1	ID	ID	ID	ID	4
Dichlorvos	<0.1	n/a	n/a	n/a	n/a	n/a
Diazinon	<0.1	ID	ID	ID	ID	0.01
Dimethoate	<0.1	ID	ID	ID	ID	0.15
Ethion	<0.1	n/a	n/a	n/a	n/a	n/a
Fenthion	<0.1	n/a	n/a	n/a	n/a	n/a
Fenitrothion	<0.1	ID	ID	ID	ID	0.001
Malathion	<0.1	ID	ID	ID	ID	0.05
Parathion (Ethyl)	<0.1	ID	ID	ID	ID	0.004
Parathion Methyl	<0.1	n/a	n/a	n/a	n/a	n/a
Pirimiphos-Ethyl[8]	<0.1	n/a	n/a	n/a	n/a	n/a
Pirimiphos-Methyl[9]	<0.1	n/a	n/a	n/a	n/a	n/a
Organochlorine pesticides (µg/L)						
Aldrin	<0.001	ID	ID	ID	ID	0.003
Trans-Chlordane[10]	<0.001	ID	ID	ID	ID	0.001
Cis-Chlordane[10]	<0.001	ID	ID	ID	ID	0.001
Oxychlordane[10]	<0.001	ID	ID	ID	ID	0.001
Gamma-BHC (Lindane)	<0.001	ID	ID	ID	ID	0.007
alpha-BHC	<0.001	n/a	n/a	n/a	n/a	n/a
beta-BHC	<0.001	n/a	n/a	n/a	n/a	n/a
delta-BHC	<0.001	n/a	n/a	n/a	n/a	n/a
p,p-DDD	<0.001	n/a	n/a	n/a	n/a	n/a
p,p-DDE	<0.001	ID	ID	ID	ID	0.0005

Parameter	Swanbourne	ANZECC/ARMCANZ (2000a) guidelines (µg/L)[1]				
	TWW	Level of protection				Low reliability value (LRV)
	16 Feb 2016	99%	95%	90%	80%	
p,p-DDT	<0.001	ID	ID	ID	ID	0.0004
Dieldrin	<0.001	ID	ID	ID	ID	0.01
Endrin	<0.001	0.004	0.008	0.01	0.02	-
Endrin Aldehyde	<0.001	n/a	n/a	n/a	n/a	n/a
Endrin ketone	<0.001	n/a	n/a	n/a	n/a	n/a
alpha-Endosulfan	<0.001	ID	ID	ID	ID	0.0002
beta-Endosulfan	<0.001	ID	ID	ID	ID	0.007
Endosulfan Sulfate[11]	<0.001	0.005	0.01	0.02	0.05	-
HCB (Hexachlorobenzene)	<0.001	ID	ID	ID	ID	0.05
Heptachlor	<0.001	ID	ID	ID	ID	0.0004
Heptachlor epoxide	<0.001	n/a	n/a	n/a	n/a	n/a
Methoxychlor	<0.001	ID	ID	ID	ID	0.004
Phenol (µg/L)						
Phenol	–	270	400	520	720	-
Nonylphenol	–	ID	ID	ID	ID	1
2-Chorophenol	–	ID	ID	ID	ID	340
2-Methylphenol	–	n/a	n/a	n/a	n/a	n/a
2,4-Dichlorophenol	–	ID	ID	ID	ID	120
2-Nitrophenol	–	n/a	n/a	n/a	n/a	n/a
4-Chloro-3-methylphenol	–	n/a	n/a	n/a	n/a	2
2,4,6-Trichlorophenol	–	ID	ID	ID	ID	34
4-Nitrophenol	–	ID	ID	ID	ID	2
2,4,5-Trichlorophenol	–	n/a	n/a	n/a	n/a	n/a
2,3,4,6-Trichlorophenol	–	ID	ID	ID	ID	10
Pentachlorophenol (PCP)	–	11	22	33	55	-
Phthalates (µg/L)						
Dimethyl phthalate	<10	ID	ID	ID	ID	3700
Diethyl phthalate	<10	ID	ID	ID	ID	900
Di-n-butyl phthalate	<10	ID	ID	ID	ID	25
Butyl benzyl phthalate	<10	n/a	n/a	n/a	n/a	n/a
Bis(2-ethylhexyl) phthalate	<20	ID	ID	ID	ID	1
PCB aroclors						
Aroclor 1016	<0.1	ID	ID	ID	ID	0.009
Aroclor 1221	<0.1	ID	ID	ID	ID	1
Aroclor 1232	<0.1	ID	ID	ID	ID	0.3
Aroclor 1242	<0.1	ID	ID	ID	ID	0.3
Aroclor 1248	<0.1	ID	ID	ID	ID	0.03
Aroclor 1254	<0.1	ID	ID	ID	ID	0.01
Aroclor 1260	<0.1	ID	ID	ID	ID	n/a
Total PCB's (as above)[12]	<0.1	ID	ID	ID	ID	n/a

Parameter	Swanbourne	ANZECC/ARMCANZ (2000a) guidelines (µg/L)[1]				
	TWW	Level of protection				Low reliability value (LRV)
	16 Feb 2016	99%	95%	90%	80%	
Chlorinated hydrocarbons (µg/L)						
2-Chloronaphthalene	–	n/a	n/a	n/a	n/a	n/a
1,4-Dichlorobenzene	–	ID	ID	ID	ID	60
1,2-Dichlorobenzene	–	ID	ID	ID	ID	160
1,3-Dichlorobenzene	–	ID	ID	ID	ID	260
Hexachlorobenzene	–	ID	ID	ID	ID	0.05
1,2,4-Trichlorobenzene	–	20	80	140	240	-
Hexachloroethane	–	ID	ID	ID	ID	290
Hexachlorocyclopentadiene	–	ID	ID	ID	ID	0.05
Hexachloro-1,3-butadiene[13]	–	ID	ID	ID	ID	0.03
Ethers (µg/L)						
4-Bromophenyl phenyl ether[14]	–	n/a	n/a	n/a	n/a	n/a
4-Chlorophenyl phenyl ether	–	n/a	n/a	n/a	n/a	n/a
Bis(2-chloroethyl)ether	–	n/a	n/a	n/a	n/a	n/a
Bis(2-chloroethoxy)methane	–	n/a	n/a	n/a	n/a	n/a
Bis(2-chloroisopropyl)ether	–	n/a	n/a	n/a	n/a	n/a
Amines, nitroaromatics nitrosamines (µg/L)						
Azobenzene	–	n/a	n/a	n/a	n/a	n/a
2,4-Dinitrotoluene	–	ID	ID	ID	ID	16
2,6-Dinitrotoluene	–	n/a	n/a	n/a	n/a	0.3
Nitrobenzene	–	ID	ID	ID	ID	550
N-Nitrosodimethylamine	–	n/a	n/a	n/a	n/a	n/a
N-Nitrosodiphenylamine	–	ID	ID	ID	ID	6
N-Nitrosodi-n-propylamine	–	n/a	n/a	n/a	n/a	n/a
Aniline	–	ID	ID	ID	ID	8
4-Chloroaniline	–	n/a	n/a	n/a	n/a	n/a
2-Nitroaniline	–	n/a	n/a	n/a	n/a	n/a
3-Nitroaniline	–	n/a	n/a	n/a	n/a	n/a
4-Nitroaniline	–	n/a	n/a	n/a	n/a	n/a
Other organics (µg/L)						
Dichlorobenzidine[15]	–	ID	ID	ID	ID	0.5
2-Methylnaphthalene	–	n/a	n/a	n/a	n/a	n/a
Isophorone	–	ID	ID	ID	ID	130
Benzyl alcohol	–	n/a	n/a	n/a	n/a	n/a
Carbazole	–	n/a	n/a	n/a	n/a	n/a
Dibenzofuran	–	n/a	n/a	n/a	n/a	n/a
BTEX (µg/L)						
Benzene	<1.0	500	700	900	1300	500
Toluene	<1.0	ID	ID	ID	ID	180
Ethylbenzene	<1.0	ID	ID	ID	ID	5

Parameter	Swanbourne	ANZECC/ARMCANZ (2000a) guidelines (µg/L)[1]				
	TWW	Level of protection				Low reliability value (LRV)
	16 Feb 2016	99%	95%	90%	80%	
Xylene[16]	<2.0	ID	ID	ID	ID	75
Total BTEX[12]	<5.0	n/a	n/a	n/a	n/a	n/a
Total petroleum hydrocarbons (TPH) (µg/L)						
TPH C6 - C9[17]	<25	ID	ID	ID	ID	n/a
TPH C10 - C14[17]	<25	ID	ID	ID	ID	n/a
TPH C15 - C28[17]	<100	ID	ID	ID	ID	n/a
TPH C29 - C36[17]	<100	ID	ID	ID	ID	n/a
Total TPH[17,18]	<250	ID	ID	ID	ID	n/a
Poly aromatic hydrocarbons (PAHs) (µg/L)						
Naphthalene	<0.01	50	70	90	120	-
Acenaphthylene	<0.01	n/a	n/a	n/a	n/a	n/a
Acenaphthene	<0.01	n/a	n/a	n/a	n/a	n/a
Fluorene	<0.01	n/a	n/a	n/a	n/a	n/a
Phenanthrene	<0.01	ID	ID	ID	ID	2
Anthracene	<0.01	ID	ID	ID	ID	0.4
Fluoranthene	<0.01	ID	ID	ID	ID	1.4
Pyrene	<0.01	n/a	n/a	n/a	n/a	n/a
Benz(a)anthracene	<0.01	n/a	n/a	n/a	n/a	n/a
Chrysene	<0.01	n/a	n/a	n/a	n/a	n/a
Benzo(b,k)fluoranthene	<0.02	n/a	n/a	n/a	n/a	n/a
Benzo(a)pyrene	<0.01	n/a	n/a	n/a	n/a	n/a
Indeno(1,2,3-cd)pyrene	<0.01	n/a	n/a	n/a	n/a	n/a
Dibenz(a,h)anthracene	<0.01	n/a	n/a	n/a	n/a	n/a
Benzo(g,h,i)perylene	<0.01	50	70	90	120	-
Surfactants (mg/L)						
Methylene blue active substances (MBAS)[19]	0.11	n/a	n/a	n/a	n/a	n/a
Miscellaneous other (mg/L unless indicated)						
Chlorine-Free	<0.01	ID	ID	ID	ID	3
Chlorine-Total	<0.01	ID	ID	ID	ID	3
Dissolved Organic Carbon (DOC)	11	n/a	n/a	n/a	n/a	n/a
Total Organic Carbon (TOC)	16	n/a	n/a	n/a	n/a	n/a
Total Suspended Solids (TSS)[20]	20	n/a	n/a	n/a	n/a	n/a
Biological Oxygen Demand (BOD)	8	n/a	n/a	n/a	n/a	n/a
pH[21]	7.9	n/a	n/a	n/a	n/a	n/a

Notes:

1. The trigger values for marine waters are from Table 3.4.1 in ANZECC/ARMCANZ (2000a). The EPA has provided advice that in WA waters where a high level of protection applies, that the 99% species protection levels should be used, with the exception of cobalt, where the 95% species protection levels is used. **Grey bold** text represents the relevant ANZECC/ARMCANZ (2000a) guideline values and **amber bold** text represents an exceedance of the ANZECC/ARMCANZ (2000a) guideline value prior to initial dilution.
2. Primary and secondary contact guideline for recreational marine waters are 35 and 230 *Enterococci* organisms/100 mL, respectively (ANZECC/ARMCANZ 2000a).
3. n/a = ANZECC/ARMCANZ (2000a) guideline or LRV not available for this parameter.

4. Primary and secondary contact guidelines for recreational marine waters 150 and 1000 faecal coliforms/100 mL (ANZECC/ARMCANZ 2000a), respectively.
5. ID = insufficient data to derive a reliable national trigger value.
6. Recreational guideline for Dicamba = 300 µg/L (Table 5.2.4; ANZECC/ARMCANZ 2000a).
7. Recreational guideline for Triclopyr = 20 µg/L (Table 5.2.4; ANZECC/ARMCANZ 2000a).
8. Recreational guideline for Pirimiphos-ethyl = 1 µg/L (Table 5.2.4; ANZECC/ARMCANZ 2000a).
9. Recreational guideline for Pirimiphos-methyl = 60 µg/L (Table 5.2.4; ANZECC/ARMCANZ 2000a).
10. Guideline values are for total chlordane though cis-chlordane is ~7 times more toxic than transchlordane (ANZECC/ARMCANZ 2000a).
11. Values are for Endosulphan, not Endosulphan sulfate (Table 3.4.1; ANZECC/ARMCANZ 2000a).
12. ANZECC/ARMCANZ (2000b) recommends using a formula to calculate total toxicity of the mixture if using total PCBs and BTEX (page 8.3-65; ANZECC/ARMCANZ 2000b).
13. Environmental Concern Level (ECL) for Hexachloro-1,3-butadiene (not LRV) (definition of ECL on page 8.3-35; page 8.3-231; ANZECC/ARMCANZ 2000b).
14. Recommended ECL for 4-Bromophenyl phenyl ether = 12 µg/L (page 8.3-232; ANZECC/ARMCANZ 2000b).
15. ECL for Dichlorobenzidine (not LRV) (page 8.3-187; ANZECC/ARMCANZ 2000b).
16. Guideline for o-Xylene = 350 µg/L, for m-xylene = 75 µg/L and for p-xylene = 200 µg/L (ANZECC/ARMZANC 2000a).
17. Guideline values are for generic oils and petroleum hydrocarbons (Table 3.4.1; ANZECC/ARMCANZ 2000a).
18. A generic estimate of 7 µg/L for a total petroleum hydrocarbon chronic value has been estimated using USEPA methods (page 8.3-297; ANZECC/ARMCANZ 2000b).
19. Recreational guideline for MBAS = 0.2 mg/L (ANZECC/ARMCANZ 2000a).
20. Suspended solids guidelines for the protection of saltwater aquaculture species = <10 mg/L (Table 4.4.2; ANZECC/ARMCANZ 2000a).
21. pH guideline range for slightly disturbed inshore marine ecosystems in southwest Australia = 8.0 to 8.4 (Table 3.3.6; ANZECC/ARMCANZ 2000a).

References

ANZECC/ARMCANZ (2000a) National Water Quality Management Strategy: Paper No 4 − Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 1 − The Guidelines (Chapters 1-7). Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, ACT, October 2000

ANZECC/ARMCANZ (2000b) National Water Quality Management Strategy: Paper No 4 − Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Volume 2 − Aquatic Ecosystems − Rationale and Background Information (Chapter 8). Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, ACT, October 2000

Appendix D – Initial dilution output

SWANBOURNE – INITIAL DILUTION MODELLING

```
/ Windows UM3. 4/06/2015 1:13:53 PM
Case 1; ambient file c:\plumes\VP plume 3.001.db; Diffuser table record 1: ----------------------------------
      Depth    Amb-cur    Amb-dir    Amb-sal    Amb-tem    Amb-pol       Decay    Far-spd    Far-dir    Disprsn
          m        m/s        deg        psu          C      kg/kg        s-1        m/s        deg   m0.67/s2
        0.0       0.07       64.0       36.09       24.1        0.0        0.0  2.1416E+8  2.1416E+8        0.0
       10.0      0.062       64.0        36.1       23.3        0.0        0.0  2.1416E+8  2.1416E+8        0.0
   P-dia  P-elev V-angle H-angle   Ports Spacing AcuteMZ ChrncMZ P-depth Ttl-flo Eff-sal    Temp Polutnt
     (m)     (m)   (deg) (N-deg)      ()      (m)     (m)     (m)     (m)   (MLD)   (psu)     (C) (kg/kg)
    0.17     1.0     0.0    26.0    20.0     5.0   100.0   150.0    10.0    65.0     0.7    24.0      0.1
Froude number:       7.83
        Depth  Amb-cur    P-dia  Polutnt   Dilutn  CL-diln   x-posn   y-posn
Step      (m)   (cm/s)      (m)  (kg/kg)       ()       ()      (m)      (m)
   0     10.0      6.2     0.17      0.1      1.0      1.0      0.0      0.0;
 100    9.467    6.241    0.965   0.0146    6.685    3.194    0.966    1.981; axial vel   0.0087
 200    3.621    6.703    3.262  0.00213    45.66    21.82    2.867    5.879; axial vel    0.046
 229    0.537    6.948    4.758   0.0012    81.07    37.75    3.623    7.427; axial vel    0.377 surface,
 :
1:13:53 PM. amb fills: 2
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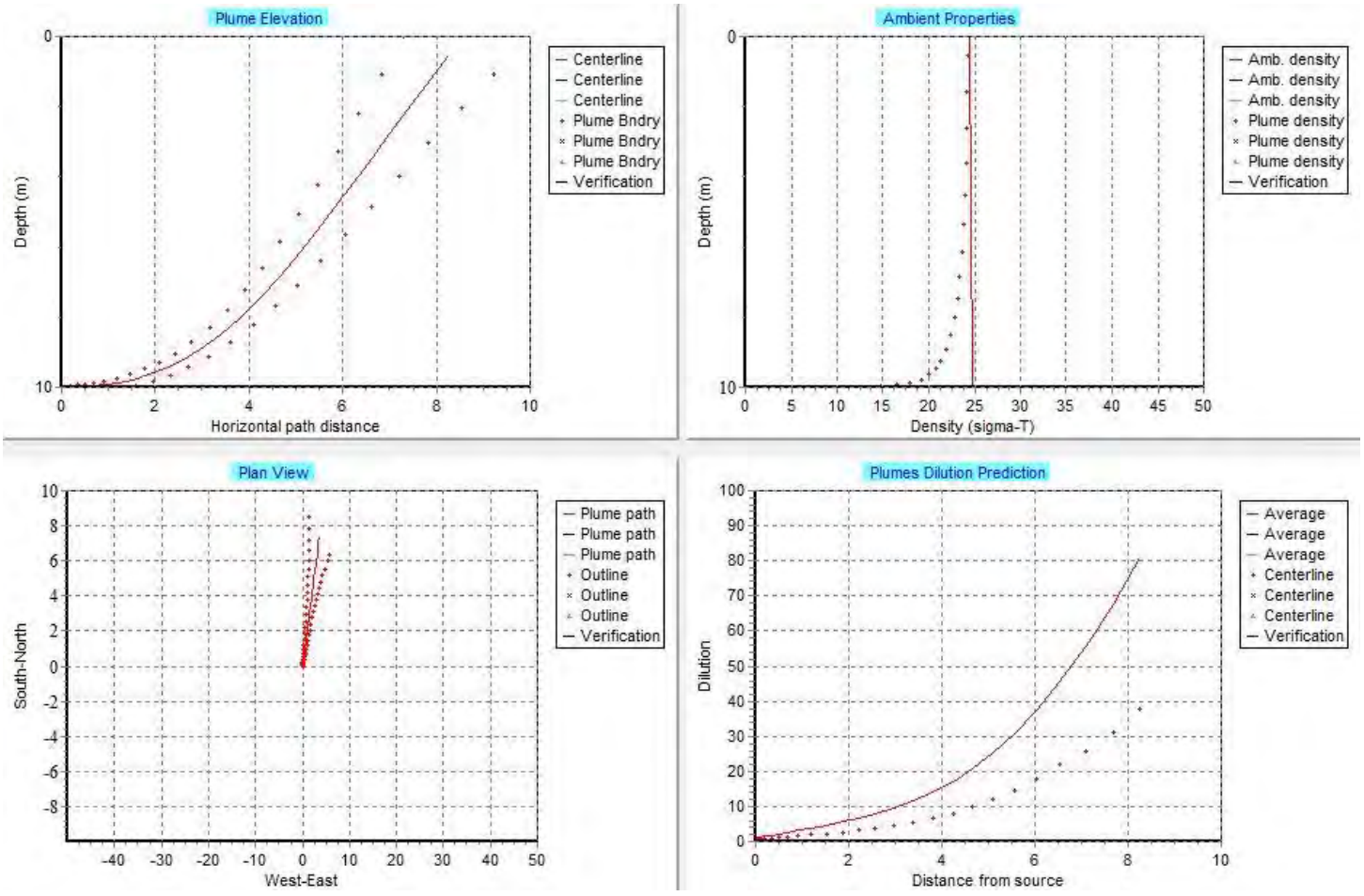

Swanbourne

```
/ UM3. 5/10/2016 10:43:40 AM
Case 1; ambient file c:\plumes\VP plume 54.001.db; Diffuser table record 1: ----------------------------------

Ambient Table:
     Depth   Amb-cur   Amb-dir   Amb-sal   Amb-tem   Amb-pol     Decay   Far-spd   Far-dir   Disprsn   Density
         m       m/s       deg       psu         C     kg/kg       s-1       m/s       deg  m0.67/s2   sigma-T
       0.0      0.13     142.9     36.31     23.11       0.0       0.0         -         -       0.0     24.92
      11.0      0.11     142.9     36.31     23.11       0.0       0.0         -         -       0.0     24.92

Diffuser table:
   P-dia  P-elev V-angle H-angle   Ports Spacing AcuteMZ ChrncMZ P-depth Ttl-flo Eff-sal    Temp Polutnt
     (m)     (m)   (deg)   (deg)     ()     (m)     (m)     (m)     (m)   (MLD)   (psu)     (C) (kg/kg)
    0.17     1.0     0.0   142.9    20.0     5.0   100.0   200.0    10.0    63.6    0.66    30.3    0.01

Simulation:
Froude number:      7.385; effleunt density (sigma-T)     -3.89; effleunt velocity     1.622(m/s);
        Depth  Amb-cur     P-dia  Polutnt   Dilutn  CL-diln   x-posn   y-posn
Step      (m)    (m/s)       (m)  (kg/kg)       ()       ()      (m)      (m)
   0     10.0    0.112      0.17     0.01      1.0      1.0      0.0      0.0;
 100    9.461    0.113     0.951  0.00138    7.069    3.163   -1.805    1.365;
 200     5.58     0.12     3.407 0.000191    51.04    20.98   -5.247    3.969;
 233    3.498    0.124     5.053 9.912E-5    98.08    37.85   -6.998    5.293; merging;
 246    2.419    0.125     6.106 7.662E-5    126.9    51.33   -7.989    6.042; matched energy radial vel =  0.109m/s;
 247    2.324    0.126     6.205 7.512E-5    129.4    52.65   -8.078    6.109; surface;
 :
10:43:40 AM. amb fills: 2
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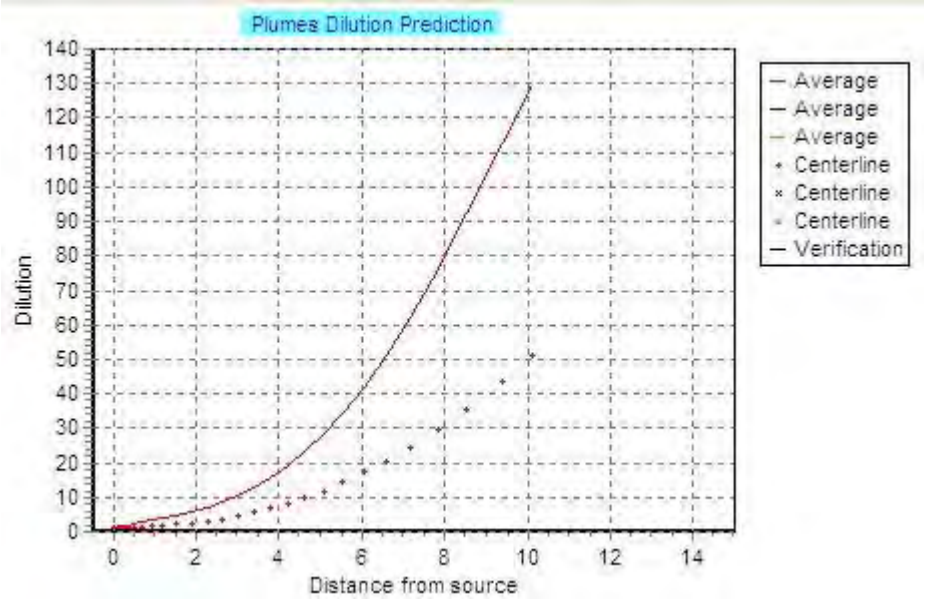
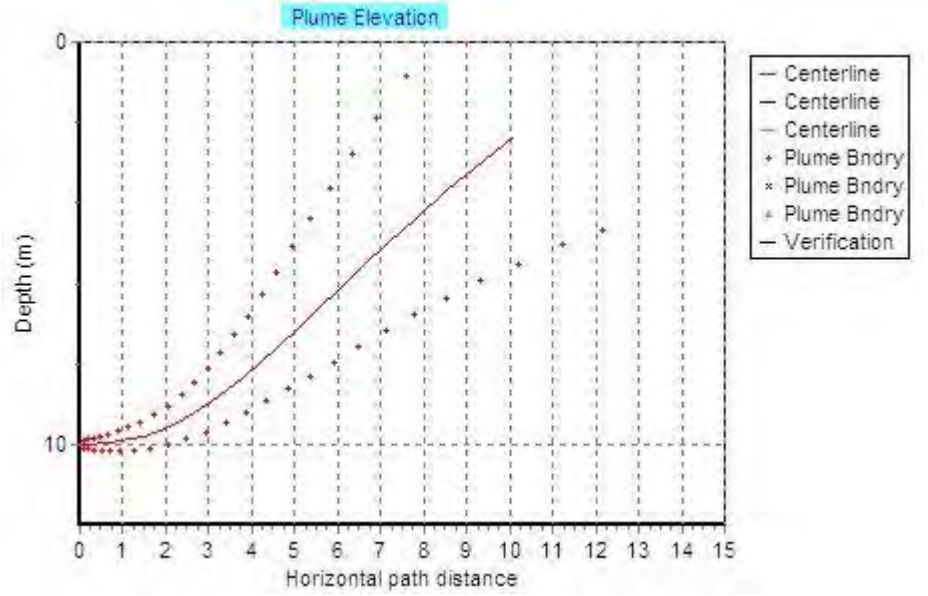
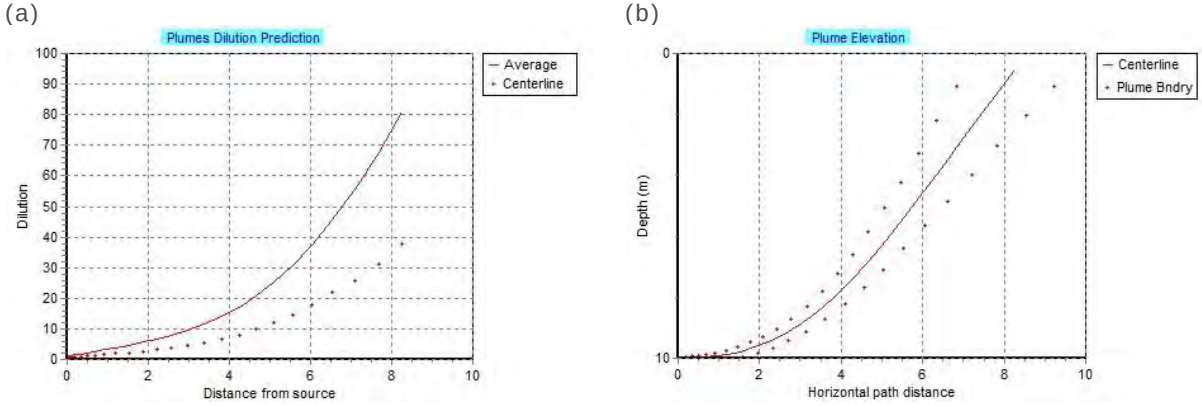




Initial dilution modelling for the ambient conditions and TWW flows at the time of TCM was done using the VPLUMES initial dilution model (see BMT Oceanica (2015) for details). The VPLUMES model is accepted for use by the United States Environmental Protection Agency (http://www.epa.gov) and captures simple features concerning the surrounding environment such as depth at point of discharge, net current and wind speed. VPLUMES is designed to predict the near-field behaviour of wastewater effluent plumes in the region where the plume first jets into the surrounding waters and then, in the case of positively buoyant plumes, rises and mixes with the surrounding waters (generally <10 m from the diffuser). Additional dilution is expected between the point that the plume reaches the surface and the notional LEPA boundary. Although initial dilution therefore underestimates the dilution at the notional LEPA boundary, it is favoured as it represents a highly conservative approach.

For the ambient conditions at the time of the survey, the modelling predicted an average initial dilution of 1:129 and a centreline dilution of 1:53 (Figure 1). The plume was predicted to first reach the surface within ~9 m (horizontal distance) from the discharge point (see the ambient boundary[1] of the plume in Figure 1.

(a) (b)



Notes:
1. a = predicted average and centreline dilution
2. b = predicted plume elevation

Figure 1 Initial dilution modelling output showing (left) predicted average and centreline dilutions and (right) predicted centreline dilution and plume elevation trajectory at Swanbourne

[1] *The ambient boundary corresponds to the plume boundary at which concentrations are estimated to be equal to ambient conditions.*

Appendix E – National Measurement Institute laboratory results

Appendix F – Detailed methodologies

1. Maintenance of Ecosystem Integrity

1.1 Ecosystem Health

The EQO for the EV 'Ecosystem Health' is aimed at maintaining ecosystem integrity and biodiversity, thereby ensuring the continued health and productivity of Perth's coastal waters (EPA 2015). There are two areas of ecological protection surrounding the Swanbourne ocean outlet; a high ecological protection area (HEPA) and a notional low ecological protection area (LEPA; Figure 1.1) (EPA 2015). The notional LEPA includes waters within a 100 m radius around the diffuser; waters outside this zone are managed as a HEPA (Figure 1.1).

A comprehensive suite of contaminants are monitored in the TWW prior to discharge (i.e. in the undiluted TWW stream), as well as a subset of contaminants within the receiving environment (i.e. in the diluted TWW plume). Monitoring against trial EQC involves:

- toxicants in TWW
- receiving water physical-chemical measures
- receiving water direct biological measures.

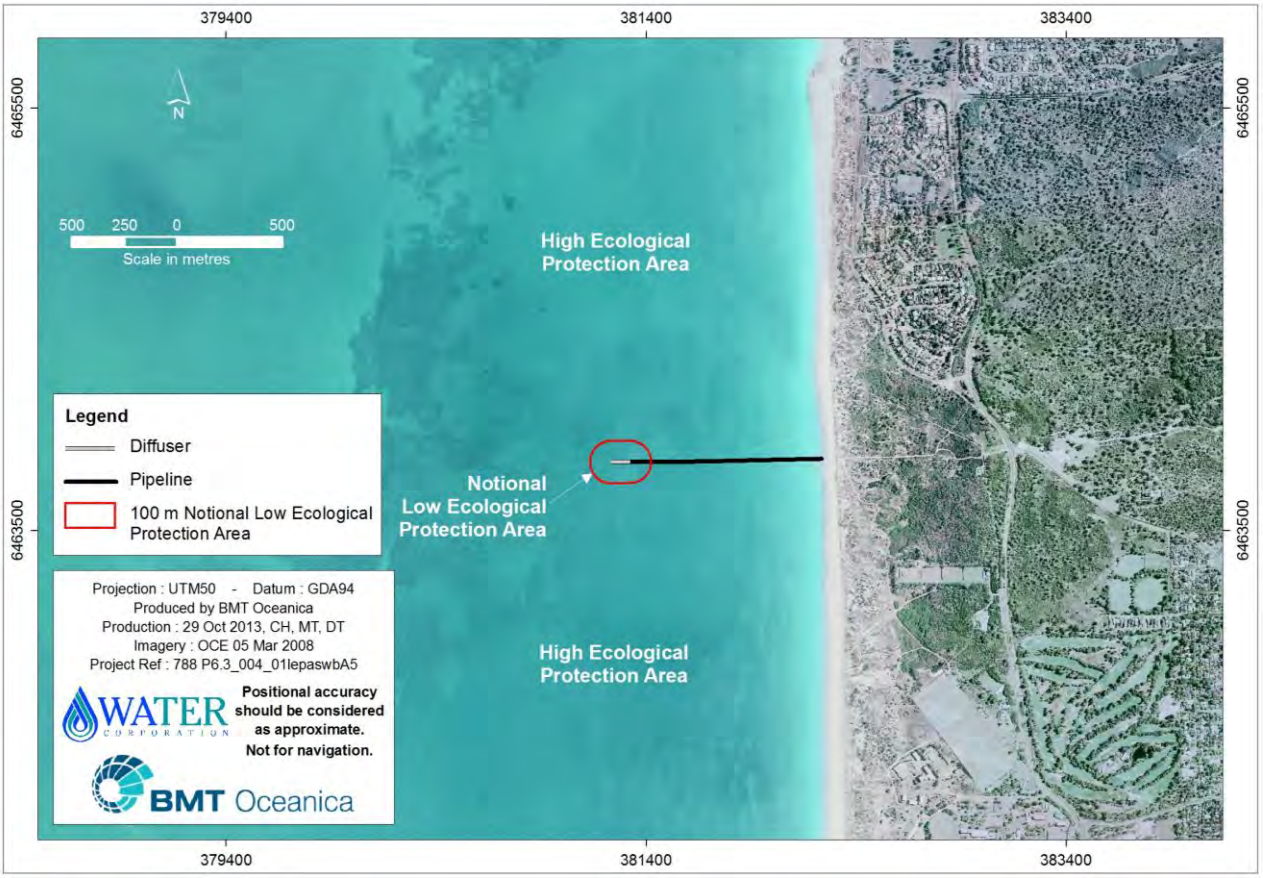


Figure 1.1 Swanbourne ocean outlet notional ecological protection boundaries

1.2 Toxicants in treated wastewater

Toxicants in TWW are assessed using four trial EQG triggers that evaluate:

- bioaccumulating toxicants in the undiluted TWW stream (EQG 1)
- non-bioaccumulating toxicants at the notional LEPA boundary (EQG 2)
- total toxicity of the mixture (TTM) for key contaminants (ammonia, copper and zinc) at the notional LEPA boundary (EQG 3)
- WET testing using various dilution levels of the TWW stream (EQG 4).

1.2.1 Comprehensive treated wastewater characterisation (CTWWC)

TWW (final effluent) from the Subiaco WWTP is analysed for a suite of parameters comprising the major contaminants of concern for the Swanbourne ocean outlet:

- nutrients (total nitrogen, ammonia, nitrate+nitrite, total phosphorus, orthophosphate)
- microbiological contaminants
- bioavailable metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver and zinc)
- pesticides and herbicides (organophosphate pesticides, organochlorine pesticides, triazine herbicides)
- polyaromatic hydrocarbons
- phthalates
- polychlorinated biphenyls
- benzene, toluene, ethylbenzene, and xylenes
- petroleum hydrocarbons
- surfactants
- dissolved organic carbon.

A 24-hour flow-weighted composite sample is obtained from the Subiaco WWTP on the same date as the ASWQS (see BMT Oceanica 2015). This sample represents an average of the final treated effluent discharged from the Subiaco WWTP for the 24 hours prior to and during the sample collection.

The bulk sample is homogenised (agitated), split into separate sample containers for the various analyte groups and handled according to the National Association of Testing Authorities (NATA)-accredited laboratory requirements for those analytes. Samples for bioavailable metals are filtered through a 0.45 µm filter prior to analysis, in accordance with Environmental Protection Authority (EPA) prescribed methods (EPA 2005b). Analyses are completed by laboratories with NATA-accredited methods, and the results are compared against ANZECC/ARMCANZ (2000) species protection guideline levels.

Initial dilution modelling

Initial dilution modelling for the ambient conditions and TWW flows at the time of TCM was done using the VPLUMES initial dilution model (see BMT Oceanica (2015) for details). The VPLUMES model is accepted for use by the United States Environmental Protection Agency (http://www.epa.gov) and captures simple features concerning the surrounding environment such as depth at point of discharge, net current and wind speed. VPLUMES is designed to predict the near-field behaviour of wastewater effluent plumes in the region where the plume first jets into the surrounding waters and then, in the case of positively buoyant plumes, rises and mixes with the surrounding waters (generally <10 m from the diffuser). Additional dilution is expected between the point that the plume reaches the surface and the notional LEPA boundary. Although initial dilution therefore underestimates the dilution at the notional LEPA boundary, it is favoured as it represents a highly conservative approach.

Total toxicity of the mixture (TTM)

The TTM calculation is an additional interpretative tool used for estimating the potential toxicity of TWW, and is used to evaluate EQG 3 for toxicants in TWW. The potential for cumulative toxic effects on marine organisms is assessed as per the ANZECC/ARMCANZ (2000) guidelines based on the effects of ammonia, copper and zinc (after initial dilution of the TWW with seawater), the three contaminants of concern most likely to exceed their respective guidelines.

$$\text{Total Toxicity of Mixture} = \frac{[\text{ammonia}]}{[\text{Trigger Value}]} + \frac{[\text{copper}]}{[\text{Trigger Value}]} + \frac{[\text{zinc}]}{[\text{Trigger Value}]}$$

The TTM must be <1 to meet the total toxicity criteria, in accordance with ANZECC/ARMCANZ (2000) guidelines. The initial mixing zone dilution calculated in the ASWQS (see above) is applied.

1.2.2 Whole of effluent toxicity (WET) testing

To meet the EQG 4 for TWW toxicants, quarterly WET testing is used to establish whether the TWW stream is toxic to marine biota. WET testing is particularly useful in the absence of reliable guidelines for toxicants that occur in low concentrations, or where the toxicity effects of contaminants are poorly understood. For example, the detection limits for pesticide analysis presently attainable by commercial laboratories in Australia are sometimes higher than the ANZECC/ARMCANZ (2000) guidelines.

WET testing involves exposing sea urchins (*Heliocidaris tuberculata*) to different concentrations of TWW effluent for ~1 hour and then measuring fertilisation success. This test has been chosen for its fast analytical turn-around time and the sea urchins' sensitivity to contaminants in TWW. The test results are used to calculate the NOEC (highest concentration where no significant effect is observed), LOEC (lowest concentration where a significant effect is observed) and the EC50 (the concentration of TWW causing 50% inhibition fertilisation rate). In some circumstances, sea urchin WET test results may act as a 'trigger' for a full suite of WET testing. This is an additional series of WET tests incorporating a suite of marine organisms from a variety of trophic levels. To trigger the full suite of WET tests, the NOEC must be ≤1.0% (equivalent to more than a 100-fold dilution).

All WET tests were carried out by NATA-accredited Ecotox Services Australasia Pty Ltd (Ecotox), Sydney, New South Wales. Twenty-four hour flow-weighted composite samples were collected quarterly (July 2014, October 2014, January 2015, April 2015) from the Subiaco WWTP, using containers supplied by Ecotox. The test dilutions of TWW used were 1.0, 1.6, 3.1, 6.3, 12.5, 25, 50 and 100%. All TWW dilutions were salt-adjusted (using artificial sea salts) to achieve marine salinities, so that only the toxicity due to the presence of contaminants was examined, not the toxic effect of freshwater on the marine organism. Testing was also undertaken on a seawater control and an artificial sea salt (brine) control.

1.3 Water quality monitoring – receiving environment

Water quality was monitored approximately fortnightly from the beginning of December to the end of March, coinciding with the summer non-river flow period. The TCM program collects data for comparison with the trial EQC for nutrients, phytoplankton biomass and physical and chemical stressors.

On each sampling occasion, a surface drogue was deployed over the centre of the ocean outlet diffuser and retrieved ~30 min later. The drift direction of the drogue was used to provide a directional vector, and samples were collected at five compliance sites located

at intervals of 0, 100, 350, 1000, and 1500 m along that vector down-current of the outlet (Figure 1.2). Samples were also collected at four reference sites.

A composite sample, representative of the top half of the water column, was collected from each site for analysis of chlorophyll-a and nutrients. Chlorophyll-a was measured using material retained on GF/C filters through which 1−5 L of water was passed. Water samples for inorganic nutrient analysis were filtered through a 0.45 µm GF/C filter. All samples were immediately placed on ice before being transport to the laboratory for analysis. Samples were analysed at Murdoch University's Marine and Freshwater Laboratory using standard laboratory analytical procedures undertaken according to NATA-accredited methods.

At each of the sites the following physio-chemical parameters were measured in situ using a YSI 6600/YSI 600XL water quality sensor or LiCor Model LI−1000 light meter:

- dissolved oxygen (DO) depth profile
- salinity depth profile
- irradiance
- temperature depth profile (for contextual purposes).

Irradiance measurements are obtained with one sensor positioned 1 m below the surface and a second sensor 7 m below the surface and the light attenuation coefficient (LAC) calculated as follows:

LAC = [$\log_{10}$ (irradiance at depth) − $\log_{10}$(irradiance at surface)/depth interval (in metres)][1]

The extent to which the EQC were met was assessed using data collected at distances ≥100 m from the ocean outlet. Sites positioned at distances >100 m from the diffuser are considered to lie within the HEPA. Any data collected inside the 100 m radius (notional LEPA) are presented for contextual purposes only.

[1] *Base 10 logs have been specified as they are generally the basis for environmental quality criteria favoured by the Office of the EPA.*

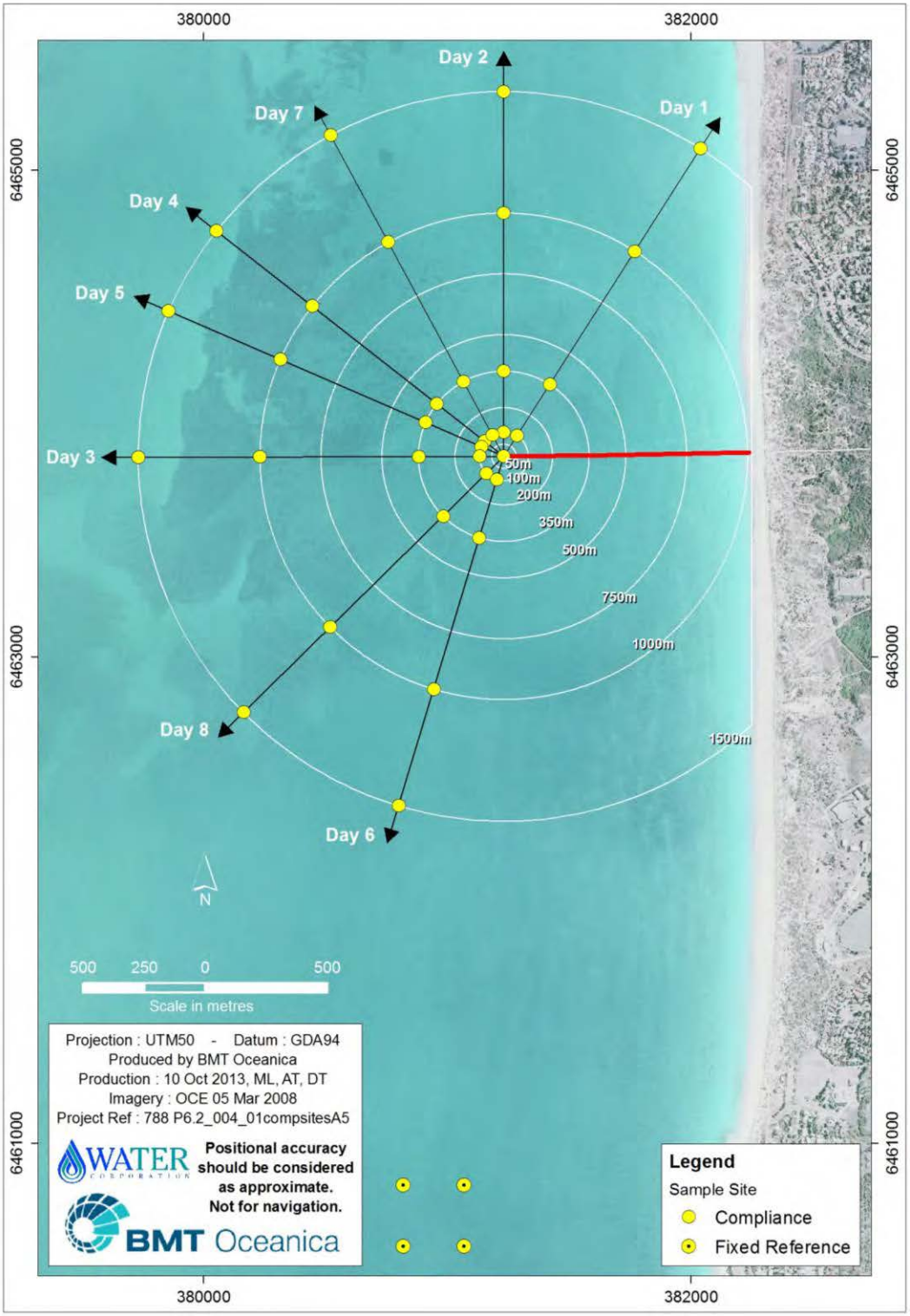


Figure 1.2 Conceptual diagram of the Trial Compliance Monitoring program showing hypothetical compliance sites and their relative distances from the outlet diffuser

2. Maintenance of Seafood for Human Consumption

2.1 Environmental Quality Objective

The EQO for the EV 'Fishing and Aquaculture' is aimed at ensuring seafood is safe for human consumption. To ensure the EQO is being met, microbiological contaminants and algal (phytoplankton) biotoxins are monitored as part of the PLOOM TCM program and the PLOOM ASWQS.

The EQO, Maintenance of Seafood Safe for Human Consumption, is primarily concerned with the harvesting and consumption of raw shellfish (i.e. filter-feeding bivalve molluscs such as oysters, mussels, clams, pipis, scallops, cockles, and razor clams) and not other forms of seafood. Human health concerns relating to consumption of shellfish are not considered an issue at Swanbourne as there is no aquaculture within 250 m of the diffuser and no known harvesting of shellfish in the waters 1–3 km offshore. The Department of Health (DoH) discourages the public from taking wild shellfish, recommending instead that shellfish are only consumed if harvested commercially and under a strict monitoring program. The DoH has further indicated that "it is impossible to guarantee the safety of eating wild shellfish without having a comprehensive monitoring program that tests the waterway concerned for harmful microorganisms and toxins" and has formally advised the Department of Environment and Conservation[2] that, in the absence of a full monitoring program, the application of the TTC criteria (EPA 2005a) is insufficient to protect those who wish to collect and eat wild shellfish.

2.2 Microbiological contaminants and algal biotoxins

The accepted method for determining whether the relevant EQC for maintenance of seafood for human consumption have been met is to monitor microbiological contaminants (measured as concentrations of thermotolerant coliforms; TTC) and algal biotoxins (measured as concentrations of phytoplankton species) at the boundary of a pre-designated management zone. Such an approach has been developed for the ocean outlets at Sepia Depression (BMT Oceanica 2014b) and Alkimos (Oceanica 2011b).

Many disease-causing organisms are transferred from human and animal faeces to water via sewage effluent, from where they can be ingested by marine fauna and infect them, adversely affecting their suitability for human consumption. TTC are one such bacteria that primarily originate in the intestines of warm-blooded animals. By testing for TTC, it can be determined whether the ocean water around Swanbourne has potentially been exposed to faecal contamination.

Nutrient enrichment as a result of TWW discharge could result in changes to the naturally occurring planktonic algae community. Although most algal blooms are considered harmless, some may contain species that produce toxins that have a potentially harmful effect on the surrounding marine environment. Species such as *Heterosigma akashiwo* and *Cryptosporidium parvum* are two such algae that cause fish mortalities.

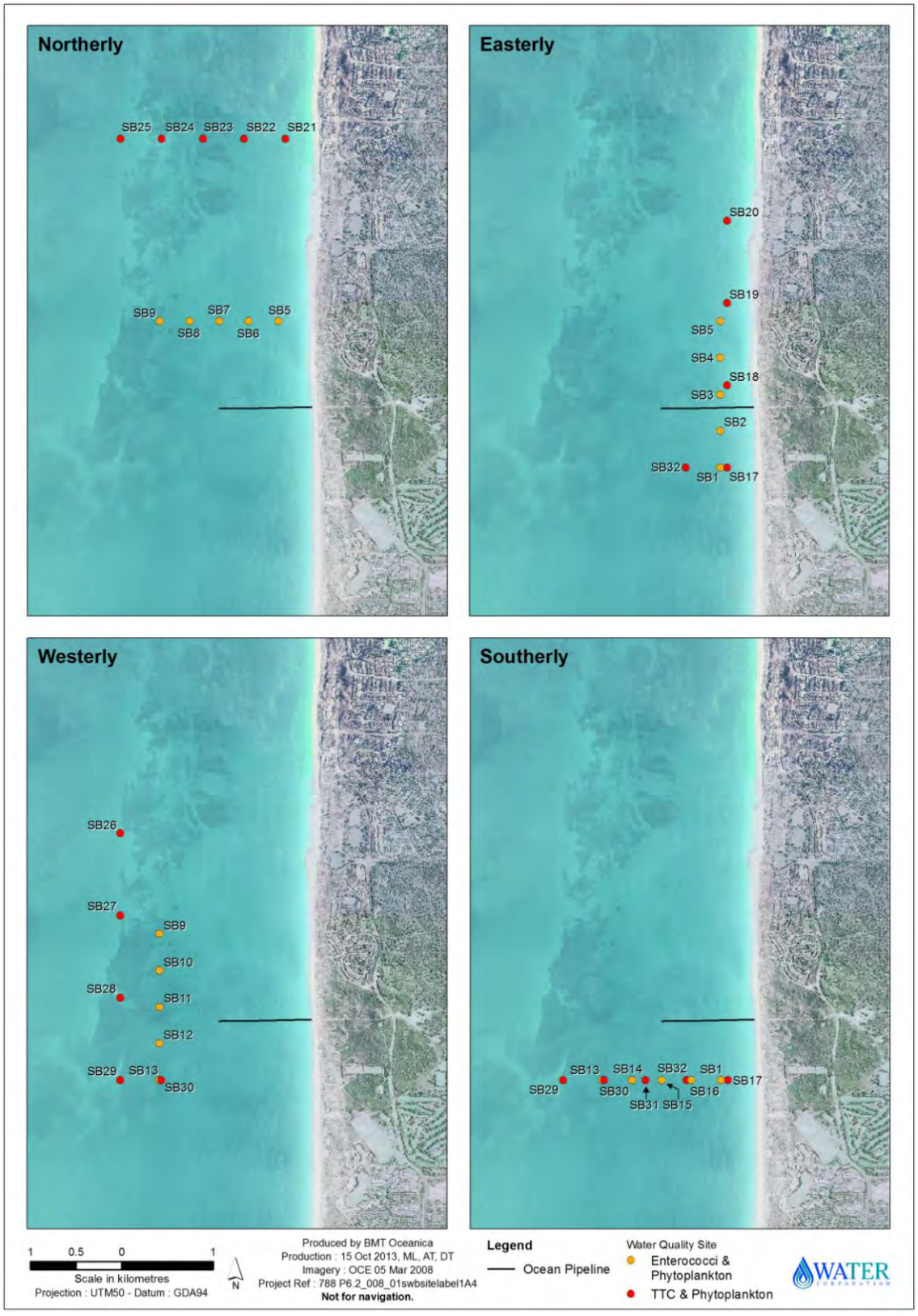
As formal management zones have yet to be established for the Swanbourne outlet, sampling for the EQO Seafood for Human Consumption was undertaken at a series of fixed monitoring sites located at the boundary of an 'observed zone of influence' (OZI; Figure 2.1, Figure 2.2). The OZI was derived from ten years of monitoring data collected at Swanbourne. Data collected at the boundaries of the OZI are used in the assessment of the EQC. The OZI allow direct comparison with outlets where similar zones have been adopted as a requirement (i.e. Alkimos and Sepia Depression). Samples were collected approximately fortnightly during the non-river flow period at five fixed sites on the boundary of the OZI immediately down-current of the diffuser, with

[2] *Now known as Department of Environment Regulation.*

site selection based on the water current direction as indicated by the drogue (Figure 2.1 and Figure 2.2). Composite water samples representative of the top half of the water column were collected and analysed for TTC and phytoplankton species.

For TTC, samples were collected in pre-sterilised bottles before being chilled in the dark to 4°C. Samples were subsequently transferred to PathWest Laboratories and analysed according to NATA-accredited methods.

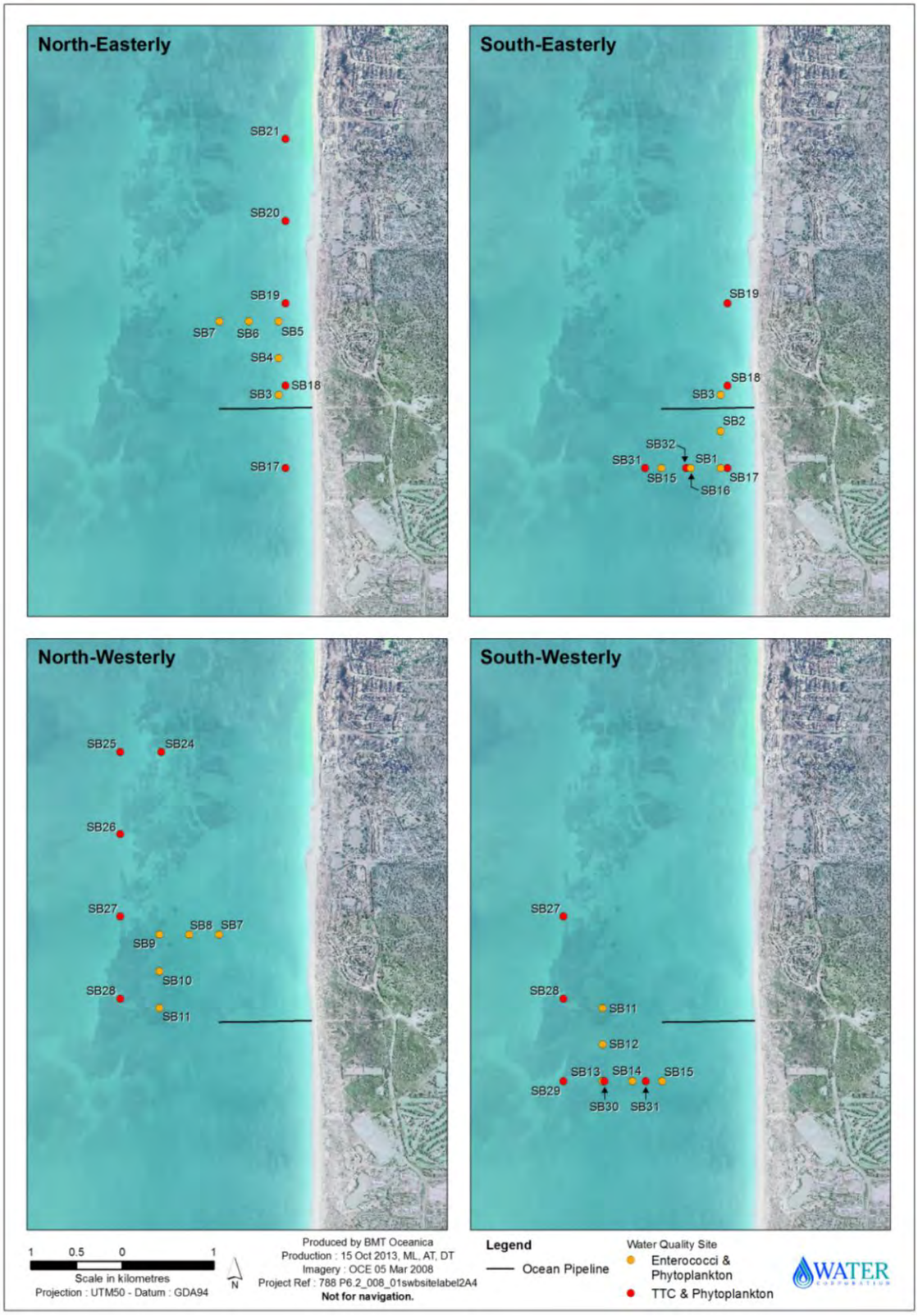
For phytoplankton, samples were preserved in Lugol's iodine solution and transported to Dalcon Environmental Laboratories for phytoplankton identification using the Utermöhl method. Phytoplankton were identified to the lowest taxonomic level possible. On each sampling date only one sample (i.e. in the direct path of the drogue) was analysed with the remaining four samples archived. In the event that toxic phytoplankton species are present at concentrations that exceed the recommended WASQAP guideline concentrations (DoF 2007), the full set of archived samples collected on that sampling occasion are also analysed (Table 2.1).



Notes:

1. Sites are located on the boundary of the observed zone of influence (OZI).

Figure 2.1 Fixed sites around the Swanbourne outlet sampled for thermotolerant coliforms (TTC), *Enterococci* spp. and phytoplankton during periods with northerly, easterly, westerly and southerly currents



Notes:

1. Sites are located on the boundary of the observed zone of influence (OZI).

Figure 2.2 Fixed sites around the Swanbourne outlet sampled for thermotolerant coliforms (TTC), *Enterococci* spp. and phytoplankton during periods with north-easterly, south-easterly, north-westerly and south-westerly currents

Table 2.1 Protocols for analysis of archived phytoplankton samples

Outcome of initial analysis	Further action
No exceedance of WASQAP[1] guideline concentrations	No analysis of archived samples
Exceedance of WASQAP guideline concentrations at both the reference site and the TCM[2] site	No analysis of archived samples
Exceedance of WASQAP guideline concentrations at the reference site, but not at the TCM site	No analysis of archived samples
Exceedance of WASQAP guideline concentrations at the TCM site but not at the reference site	Additional samples analysed

Notes:
1. Western Australian Shellfish Quality Assurance Program (DoF 2007).
2. Trial Compliance Monitoring.

3. Maintenance of Primary and Secondary Contact Recreation

3.1 Environmental Quality Objective

The EQOs for the EV 'Recreation and Aesthetics' are aimed at ensuring Perth's coastal waters are safe for primary and secondary contact recreation activities such as swimming and boating. To meet this objective, water quality around the Swanbourne outlet is to be maintained so that:

- primary contact recreation (e.g. swimming) is safe in all waters except areas designated otherwise
- secondary contact recreation (e.g. boating) is safe in all waters except areas designated otherwise.

A formal area where contact recreation is not recommended has not been established for the area surrounding the Swanbourne outlet. Sampling for this EQO was therefore undertaken at a series of fixed monitoring sites located at the boundary of the OZI, as described in Section 2.2. As the maintenance of primary contact recreation EQO requires a higher water quality standard to be maintained than secondary contact recreation EQO, by default, it is assumed that if primary contact recreation EQSs are met, secondary contact recreation EQSs will also be achieved.

3.2 Microbiological contaminants and algal biotoxins

The accepted method for determining whether the EQC for primary and secondary contact recreation have been met is to monitor microbiological contaminants (measured as numbers of faecal streptococci) and algal toxins (measured as numbers of phytoplankton cells) at the boundary of a pre-designated management zone. Such an approach has been developed for the ocean outlets at Sepia Depression and Alkimos.

Disease-causing microorganisms (pathogens) associated with bathing areas include salmonellae, shigellae, enteropathogenic *Escherichia coli*, cysts of *Entamoeba histolytica*, parasite ova, enteroviruses and infectious hepatitis (Hart 1974, McNeill 1985; cited in ANZECC/ARMCANZ 2000). The most common types of diseases associated with water-borne pathogens are eye, ear, nose and throat infections, skin diseases and gastrointestinal disorders (ANZECC/ARMCANZ 2000). Detecting faecal pathogens within routine water samples is difficult and often 'indicator' micro-organisms (such as *Enterococci* spp.) are used to assess the health risks associated with pathogens in recreational waters (Elliot & Colwell 1985; cited in ANZECC/ARMCANZ 2000).

Algal blooms can be harmful to human/animal health if encountered via ingestion or skin contact. For this reason, phytoplankton cell concentrations are monitored in the TCM program to ensure concentrations are within acceptable guidelines limits (EPA 2005b).

Microbiological contaminants were sampled for approximately fortnightly at a series of fixed monitoring sites on the OZI boundary (refer Section 2.2, Figure 2.1 and Figure 2.2). Samples were collected during the non-river flow period at five fixed sites located immediately down-current of the diffuser, with site selection based on the water current direction as indicated by the drogue. Composite water samples representative of the top half of the water column were collected for faecal streptococci (*Enterococci* spp.) and phytoplankton cell concentrations.

Enterococci spp. samples were collected in pre-sterilised bottles before being chilled to 4°C and placed in the dark. On completion of sampling, the samples were transferred to PathWest laboratories and analysed according to NATA-accredited methods.

For phytoplankton, samples were collected, preserved and analysed in the manner described in Section 2.2.

Appendix G – Ecotox Australasia laboratory results

Appendix H – Marine and Freshwater Research Laboratory results

Appendix I – Site locations and coordinates

Site Coordinates

Swanbourne trial compliance monitoring (TCM) reference and seasonal monitoring site location details and water quality parameters measured at the different sites

Site Code	Location with Respect to Outlet	Parameters Measured	Easting	Northing
Intensive Summer Water Quality ('Trial Compliance') Monitoring				
SBR1	Reference Site ≈ 4,000 m south	Nutrients; Phytoplankton; Water column profiles	380819	6460825
SBR2	Reference Site ≈ 4,000 m south	Nutrients; Phytoplankton; Water column profiles	381069	6460830
SBR3	Reference Site ≈ 4,000 m south	Nutrients; Phytoplankton; Water column profiles	380825	6460579
SBR4	Reference Site ≈ 4,000 m south	Nutrients; Phytoplankton; Water column profiles	381067	6460579

Datum: UTM WGS84 Zone 50

Swanbourne summer trial compliance monitoring (TCM) sites and their relative distances from the outlet diffuser

Date	Site Code - Distance from outlet diffuser	Easting	Northing
03/12/2015	SBT-0	381281	6463821
	SBT-100	381313	6463926
	SBT-350	381393	6464160
	SBT-1000	381597	6464785
	SBT-1500	381765	6465251
11/12/2015	SBT-0	381279	6463826
	SBT-100	381145	6463774
	SBT-350	380909	6463687
	SBT-1000	380301	6463447
	SBT-1500	379831	6463278
07/01/2016	SBT-0	381278	6463828
	SBT-100	381196	6463731
	SBT-350	381030	6463542
	SBT-1000	380591	6463053
	SBT-1500	380268	6462682
28/01/2016	SBT-0	381278	6463825
	SBT-100	381176	6463908
	SBT-350	380988	6464071
	SBT-1000	380488	6464488
	SBT-1500	380101	6464813
11/02/2016	SBT-0	381275	6463822
	SBT-100	381376	6463914
	SBT-350	381559	6464081
	SBT-1000	382041	6464520
	SBT-1260	382164	6464672
23/02/2016	SBT-0	381277	6463820
	SBT-100	381149	6463767
	SBT-350	380920	6463662
	SBT-1000	380331	6463392
	SBT-1500	379872	6463183
01/03/2016	SBT-0	381275	6463823
	SBT-100	381262	6463925
	SBT-350	381225	6464170
	SBT-1000	381131	6464815
	SBT-1500	381054	6465305
18/03/2016	SBT-0	381278	6463823
	SBT-100	381147	6463876
	SBT-350	380913	6463969
	SBT-1000	380308	6464201
	SBT-1300	379825	6464381

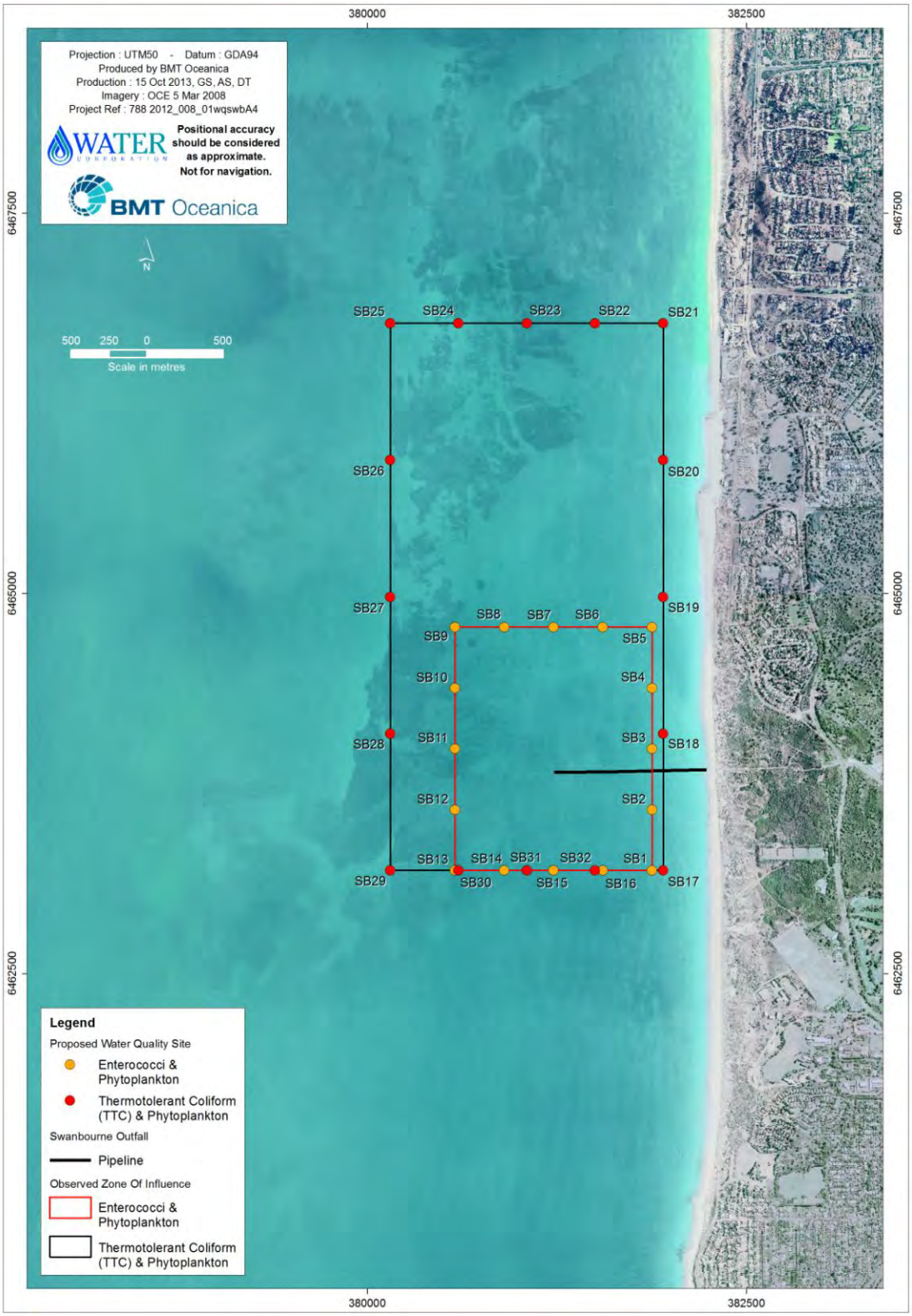
Datum: UTM WGS84 Zone 50

Notes:

1. The location of TCM potential impact sites are determined based on the direction of the surface current on the sampling day.

Swanbourne microbial and phytoplankton monitoring sites at the boundary of the observed zone of influence for contact recreation (1-16) and human consumption (17-32)

Site	Easting	Northing
SB1	381878	6463177
SB10	380578	6464377
SB11	380578	6463977
SB12	380578	6463577
SB13	380578	6463177
SB14	380903	6463177
SB15	381228	6463177
SB16	381553	6463177
SB17	381952	6463177
SB18	381952	6464077
SB19	381952	6464977
SB2	381878	6463577
SB20	381952	6465877
SB21	381952	6466777
SB22	381502	6466777
SB23	381052	6466777
SB24	380602	6466777
SB25	380152	6466777
SB26	380152	6465877
SB27	380152	6464977
SB28	380152	6464077
SB29	380152	6463177
SB3	381878	6463977
SB30	380602	6463177
SB31	381052	6463177
SB32	381502	6463177
SB4	381878	6464377
SB5	381878	6464777
SB6	381553	6464777
SB7	381228	6464777
SB8	380903	6464777
SB9	380578	6464777



Note:

1. On each sampling occasion, samples are collected down-current of the diffuser at a subset of five fixed monitoring sites located at the observed zone of influence boundary. The sites are selected based on the water current direction as indicated by a drogue release.

Fixed sites around the Swanbourne outlet sampled for thermotolerant coliforms, *Enterococci* spp. and algal (phytoplankton) toxins in relation to the observed zone of influence

Appendix J – PathWest Microbiological Laboratory results

Appendix K – Dalcon Environmental Laboratory results

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